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THE PLAGUE GRASSHOPPER.

(*AUSTROICETES JUNGI* BRANCSIK.)

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INTRODUCTION.

The term locust is frequently applied to the various forms of Acridids which cause economic loss in Australia, but although at best the distinction between grasshoppers and locusts is rather unsatisfactory, the latter name is generally reserved for those members of the group which display the true phase phenomena, having a distinct solitary and gregarious form and undertaking extensive mass migrations.

The Migratory Locust (*Locusta migratory* Lin.) is the best known member of the true locust group and is represented by sub-specific forms in every continent save America. In Australia, however, its range is limited to the extreme north and swarms appear only occasionally.

Several species of what are sometimes called gregarious grasshoppers are, however, responsible for heavy losses in this continent and the species chiefly concerned are *Chortoicetes terminifera*, Walk, and *Austroicetes jungi*, Branc. Both insects occur in Western Australia, but the one which has caused most damage in the agricultural districts is *Austroicetes jungi* and it is to this species in particular that the following remarks apply.

DESCRIPTION OF SPECIES.

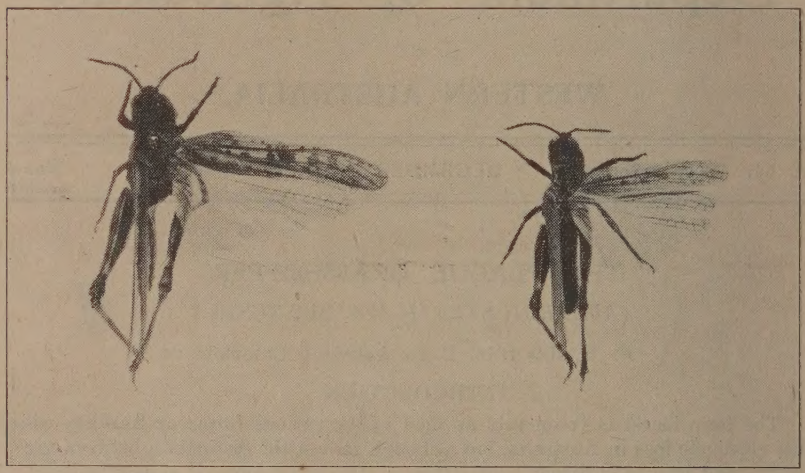
Adults.

The female measures a little over an inch (27 m.m.) in length. The elytra (fore wings) are light brown mottled with darker brown and the thorax is similarly coloured. The hind wings are clear, but a slight thickening of the veins near the apex of the wing gives a faint impression of clouding in some specimens. The femur (thigh) of the hind leg is brown marked with blackish bands; the tibia (shin) is yellowish with a light band at the base. This feature is noticeable in both sexes and in all instars.

The male is smaller than the female, measuring about three-quarters of an inch (22 m.m.) in length. The wings are spotted brown as in the female, but the predominating body colour is lemon yellow. The first and second pairs of legs are yellow, the hind legs being of a similar colour, but banded with very dark brown.

Habits of the Adults.

For several days following the final moult the adults undertake only hop-like flights, but the distance travelled gradually increases as they mature, and the warm weather stimulates them to further activity. In the adult stage the grasshopper presents its greatest menace, for then its powers of dispersal are at their maximum and control measures are practically useless where large areas are implicated.



Female. Male.

Adult grasshoppers (*Austroicetes jungi*, Branc.). (Original.)

Extensive migratory flights are not undertaken, the insects rather spreading at random and congregating wherever the food supply is most favourable, and their maximum range is probably not more than 15 or 20 miles. They show a preference for weeds and grasses rather than cereal crops and will pass through the latter, eating Cape weed, barley grass, etc., first. The flag of the crop is next attacked, and by this time the season is usually so advanced that most green fodder, other than cultivated crops, has died and dried off. The crops then commence to turn colour and ripen and the last portion of the stalk to lose its green tinge is just below the ear. This presents an attractive morsel to the hungry hoppers, who chew through the stem at this spot, and although the wheat heads themselves may not be eaten, many of them fall to the ground and so escape the harvester.

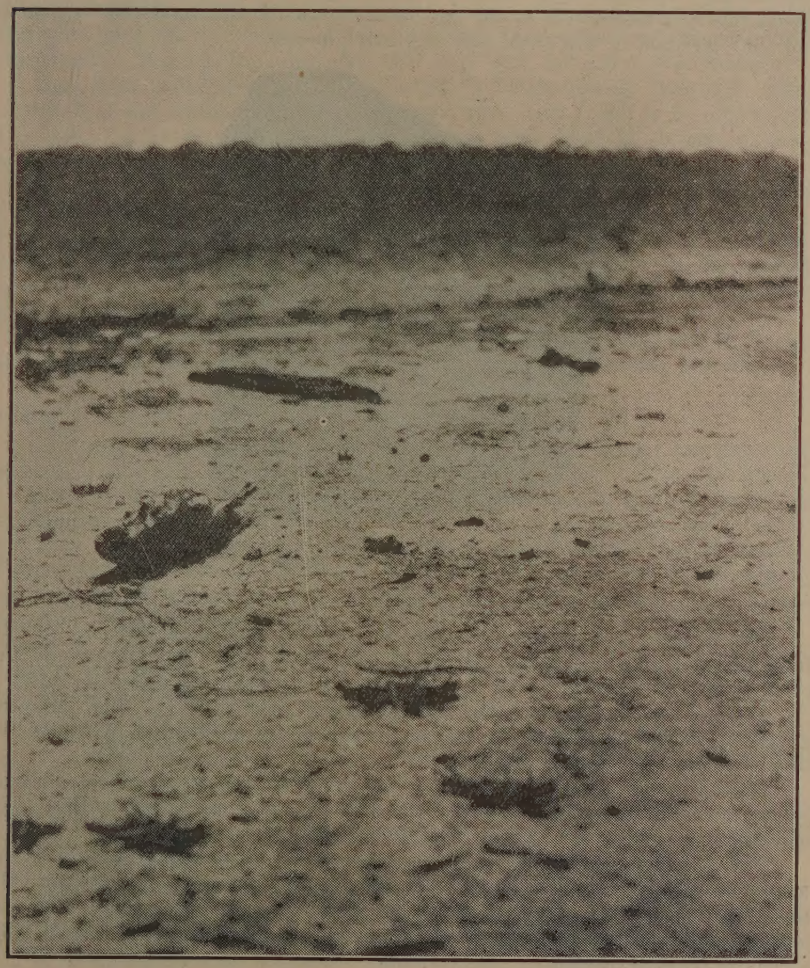
Breeding Habits.

The grasshopper lays its eggs in almost any kind of soil so long as it is compact and free from dense cover. Sandy soil and heavily grassed areas are avoided, as is dense forest and scrub country, but sparsely timbered land or narrow timber belts with bare open patches often afford good nesting sites. Roadsides, railway embankments, reserves, commonages and similar hard undisturbed localities are favourite breeding areas.

The female bores into the ground by means of hard chitinous valves situated at the end of the abdomen and a frothy substance is exuded as a lubricant during the operation and to form a lining to the egg pod.

A large number of males crowd around the female while she is laying and the accompanying photograph shows the clumps of males surrounding individual females. About 20 eggs are placed in each pod. They are yellowish white in

colour, slightly crescent shaped and about 3/16ths of an inch (4 m.m.) in length. The mouth of the egg pod is capped with soil cemented together by the frothy secretion exuded by the female and this cap is bodily lifted when the young hoppers emerge. The pod measures a little under ¾in. (16 m.m.) in length.



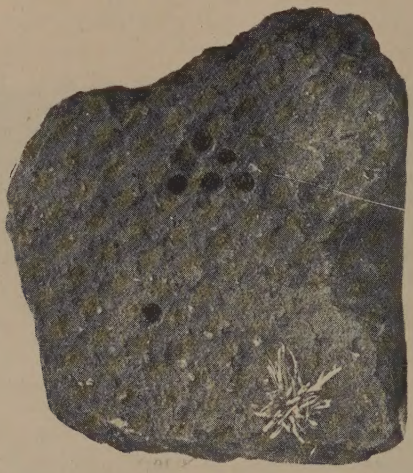
The three dark masses in foreground show clumps of males surrounding female in process of egg laying.

(Original.)

Larval Stages.

When it first issues from the egg the young hopper is clothed in a tight fitting white sheath and the larva is known as the vermiform larva because it can only progress by means of worm-like wriggles. Almost immediately after hatching the vermiform larva undergoes what is known as the intermediate moult and the little white casts can often be seen close by the holes from which the hoppers have emerged. The hopper is now said to be in its first larval instar and

resembles the adult, save for the fact that it is very small and lacks wings. At first it is light in colour but very soon changes to a brown of varying intensity. Five larval instars are passed through, the insects changing from one to the other by means of an ecdysis or moult. It is in the third instar that the wing buds and rudimentary venation first become really evident but slight lobes on the mesonotum and metanotum in the 2nd instar mark the origin of the wing pads and they increase in size with each successive moult.



(Original.)

Soil showing uncapped grasshopper egg pods from which young have issued.

Period of Emergence and Duration of Life.

The laying period varies according to seasonal conditions but may extend from September to November. Only one generation occurs per annum and the progeny from the spring laying do not emerge until about the following July.

The pre-winged stage occupies approximately eight weeks so that hoppers issuing at the end of July will be mature by the end of September and as adults they may live another six weeks.

Hatching may extend over a period of several weeks, the weather conditions having an important influence upon the rate of emergence. Due to this fact hoppers in various stages of development may be present in one area.

The grasshoppers display gregarious tendencies throughout life, clustering together especially when dull or windy weather conditions are prevailing. In the later instars this gregarious tendency becomes more pronounced and just before maturity the hoppers may be seen moving in bands or armies as if with a definite purpose in view.

Factors Affecting the Hatching of Eggs.

Soil moisture and temperature are the chief factors controlling the hatching of grasshopper eggs and it seems evident that we owe the absence of a second generation (as occurs with *chortoicetes terminifera* in parts of Eastern Australia) to the sparsity of summer rains in our wheat belt.

Much more information is necessary to demonstrate the exact influence which moisture has upon the eggs, but from observations made in the field, together with laboratory experiments, it is evident that excessive moisture is injurious to the eggs but that a certain amount is essential for their development.

Egg pods known to have been subjected to heavy flooding for protracted periods failed to produce young and many of the eggs were found to have become mouldy. Eggs collected in the field (Mukinbudin) on February 2nd, 1937, were kept under dry conditions until the 1st of May and from then on the soil was moistened. The first hoppers emerged on May 22nd and others continued to do so until June 12th. Other eggs collected on June 12th and kept under moist conditions gave rise to hoppers on July 14th with further batches emerging until August 26th. This was the latest date that eggs were hatched in the laboratory.

Eggs kept under dry conditions failed to hatch during 1936 and when moistened at the beginning of the 1937 season they were found to be non viable. It is likely however that under field conditions, eggs could in suitable circumstances last over for at least two seasons.

From the above results it will be seen that early autumn rains would have a tendency either to hatch the hoppers early, or if sufficiently heavy, cause mortality in the eggs. Early hoppers would have the severe winter conditions to contend with and the likelihood of plague resulting would be minimised. In the case of drought years the eggs are hatched by light winter rains and the mild weather favours the maximum development of the swarm.

Soil erosion in places has caused the egg pods to become exposed above the surface of the ground and in such cases the eggs were found to have perished.

Records of Grasshopper Outbreaks in Western Australia.

It is only in comparatively recent years that this grasshopper has become a serious economic pest, and several factors have combined to bring about such a state of affairs. As it is a native insect it has always been present in parts of the State, but only under certain conditions does it assume plague proportions, and observations show that climate has an important influence upon the appearance of harmful swarms. Little accurate information is available concerning the early outbreaks of this insect, as several species were confused by pioneer systematists, and it is not clear from records to which species certain outbreaks can be referred. However, as far back as August, 1922, swarms of grasshoppers were reported from Kununoppin, Nungarin and Merredin in the North-Eastern Wheat Belt, and there is little doubt that *Austroicetes jungi* was the species concerned.

1923: Hoppers were reported in July from Bencubbin and Nungarin and a month later from Nokaning. Winged swarms were reported in October at Nungarin and Lake Brown.

1924: Hoppers in August at Welbungin and Bencubbin and further reports were received in September from Nokaning, Nungarin, Westonia and Kalkalling.

1925: A decided increase upon the previous three years, which had been rather dry. August—Outbreaks reported from Nungarin, Mullewa, Westonia, Lake Yealering and Bencubbin. September—Reports from Kalkalling and Merredin. Other centres, including Toodyay and Northam, suffered invasions later in the year but sufficient information is not available to decide what species was concerned.

1926: July—Mingenew and Bencubbin. August—Mullewa. September—Nokaning. Reported scarce at Kununoppin, Bencubbin and Lake Brown.

1927: August—Bencubbin, Nokaning.

1928: August—Lake Brown, Ghooli, Southern Cross, Bullfinch. September—Kununoppin.

1929 and 1930: No reports.

1931: September—Kurrawang, Coolgardie area. October—Small outbreaks at Mukinbudin, Talgomine, Wilgoyne and Warralackin, Beverley, Wongan Hills, Nungarin and North Bencubbin. Bad outbreaks occurred in November at Southern Cross and Bullfinch.

1932: October—Mullewa and reported to be "getting worse year by year."

1933: Mild outbreaks at Kununoppin, Lake Brown, Welbungin and Narembeen.

1934: August—Nungarin and Mukinbudin. Mild outbreak at Koorda.

1935: May—Mingenew. September—Mukinbudin, Bencubbin, Boodarockin, Beacon, Southern Cross, Marvel Loch. October—Nungarin, Kununoppin, Lake Brown, Coorow, Merredin, Narembeen. November—Kondinin, Warralackin.

1936: The major portion of the north-eastern wheat belt. The hoppers extended westward to about Wyalkatchem with a southern extension to Narembeen and South Kumminin and a slight outbreak at Pingrup and Wickepin.

1937: This outbreak proved to be even more extensive than that of 1936, swarms occurring as far west as Ajana and Northampton in the northern agricultural districts and extending diagonally across the state to Corrigin in the South.

From the foregoing review it will be seen that grasshoppers were reported in numbers in the wheat belt in 1922 and that by 1925 they had assumed plague proportions in various centres. Isolated outbreaks occurred in subsequent years but widespread damage was not sustained until 1935, and in the two following years the situation became increasingly serious.

Factors influencing the occurrence of plague outbreak of Austroicetes jungi in Western Australia.

A study of the climatic conditions for the plague years shows that the rainfall was light and this appears to have had a favourable influence upon the hatching and development of the insects. Another factor, however, has had a very important influence upon the incidence of grasshoppers in these areas. Following the financial depression of 1929, much land which had been normally kept under cultivation was allowed to lie idle. The effect of the low prices was accentuated by a succession of drought years, and this led to a general decline in agricultural activities in all districts but more particularly in those areas where the margin of safety was least evident. In the boom years preceding the depression, agriculture in Western Australia spread at a very rapid rate and extensive clearing took place in all parts of the wheat belt. Grasshoppers had always been present in these areas in small numbers, but forest and scrub country was not favourable to their multiplication and food was relatively scarce. The clearing of the country exposed vast areas suitable for egg laying and the grass which this land supported provided an ample food supply for the increasing insect population. As long as high prices and good seasons stimulated farming activities the menace of these potential breeding grounds was not apparent, and reserves, ringbarked areas, roadsides, etc., were the only places where hoppers appeared, but when, following depression and drought, abandoned farms became numerous, the grasshopper problem became one of paramount importance. The large areas of land left idle in most cases did not revert to bush again, and were of such a nature that the longer they were left untouched the less herbage they supported, thus yearly increasing the breeding grounds available for the pest.

This agricultural aspect of the problem is by no means a local one for Uvarov (1928) states that "the last enormous outbreak of grasshoppers all over Siberia and in the Ural Region was to a great extent due to the general decline in agriculture in that area during the revolution and civil war . . . . There is some vague indication that the present system of agriculture in Siberia, where lands are left to lie fallow for several years without being disturbed, and this in the immediate vicinity of crops, is highly favourable to the development of some species, notably the Siberian grasshopper . . . . Thorough ecological investigations are urgently wanted, to be followed by experimental work on the influence of various agricultural methods on different species of grasshoppers."

Physical Environment.

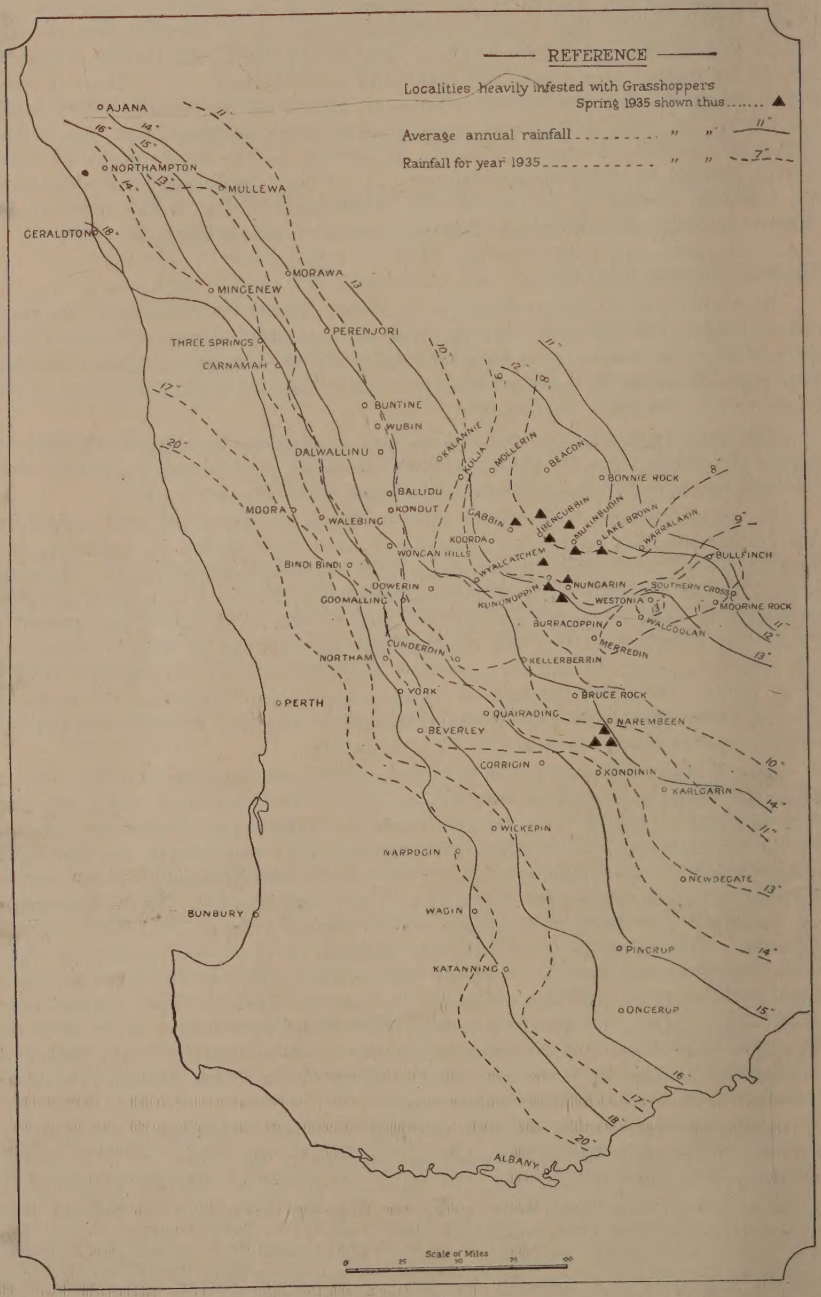
Rainfall.—The accompanying maps show the general distribution of the rainfall throughout the State for average and various specific years. The chief features to be noted in connection with the rainfall are the scarcity of regular summer rains over the majority of the grasshopper-infested areas and the association of the hoppers with the light rainfall belt.

The importance of rain in insect ecology as stressed by Davidson (1936) is largely dependent upon its ability to maintain plant growth and to provide suitable soil moisture for the development of eggs deposited in the soil.

In colder climates temperature may be the most important unit governing insect outbreaks, but as far as Australia is concerned rainfall is frequently the limiting factor, and especially is this so with regard to grasshoppers. Rainfall alone is not an adequate guide to the soil moisture or humidity of a given area, as temperature, wind intensity, evaporation, etc., should all be taken into consideration. Dr. Davidson (1934) has discussed the effectiveness of rain in respect to soil moisture, using the ratio of monthly precipitation over evaporation (P/E) as an index. Owing to the lack of meteorological data throughout the areas at present under discussion this formula cannot be applied, and the straight-out rainfall returns alone are available for comparison.

Map 1 shows the average distribution of rain throughout the State over a period of years, and also the rainfall for 1935. Localities from which hoppers were reported in plague form are also marked. Maps 2 and 3 show the rainfall for the first seven months of the years 1936 and 1937 respectively, together with average rainfall over a number of years for a seven-months period. The localities reported as plague centres for 1936 and 1937 are also recorded. When these maps are examined the drought condition which prevailed from 1935-1937 will be apparent. The reason for comparing the rainfalls up to the end of July is that by this date the majority of hoppers have usually hatched, and it is the rain which falls prior to this date which has the greatest influence upon the hatching of the eggs. When the annual rainfall is considered as a whole, heavy rains at the end of the season may compensate for dry conditions earlier in the year and so bring the average up to normal, thus masking the fact that drought conditions prevailed at the time of hopper emergence.

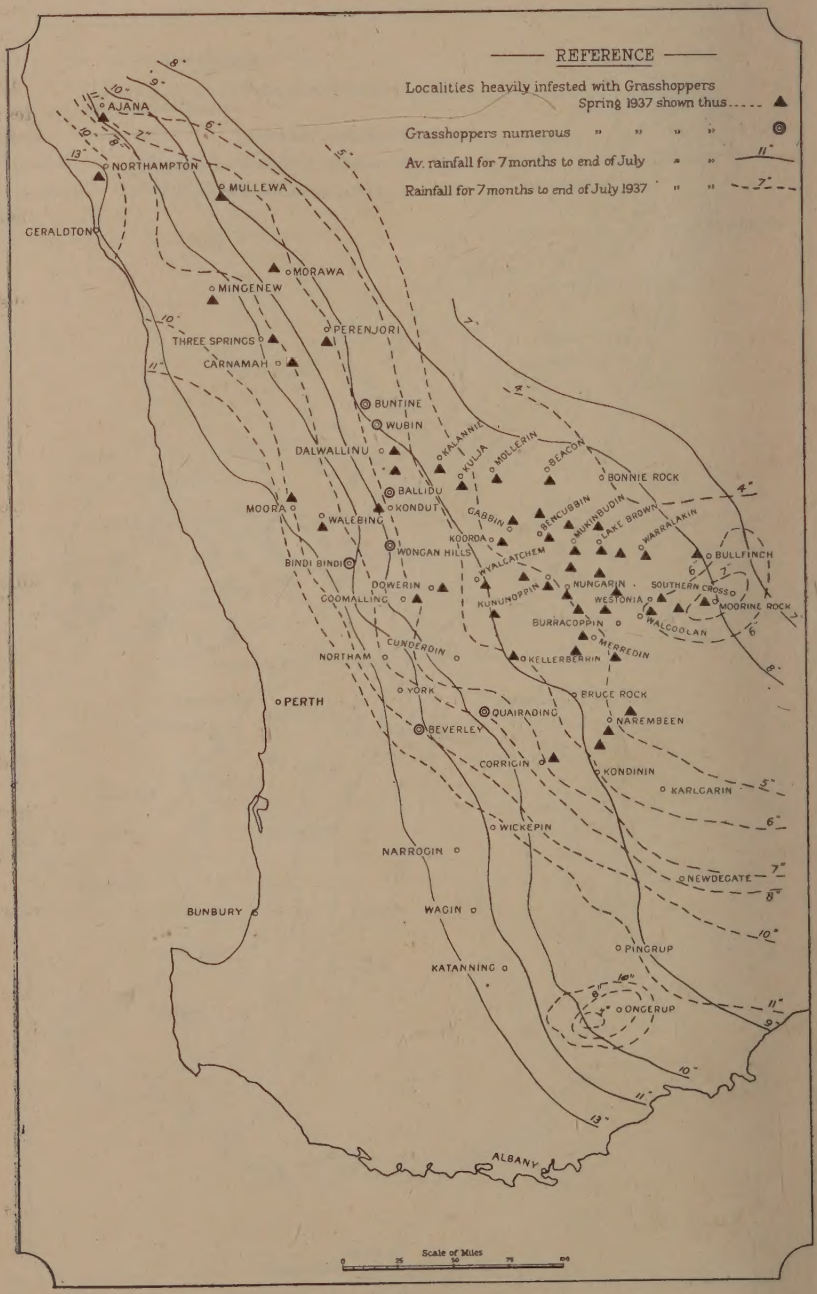
Although from the information available it is quite impossible accurately to map the distribution of the grasshopper throughout the State, or to compare, excepting in a very general way, the relative severity of different outbreaks, a glance at the accompanying maps will show that the infestation has become progressively worse since 1935, coinciding with a run of three dry seasons. Also the pest has moved steadily westward. This is not to say that the grasshopper has actually migrated in a westerly direction to any great extent, but rather that conditions suitable for its multiplication have edged westward and the normal local inhabitants have consequently multiplied so as to assume plague proportions.


REFERENCE
Localities heavily infested with Grasshoppers Spring 1935 shown thus.....
Average annual rainfall..... " "
Rainfall for year 1935..... " "
AJANA
NORTHAMPTON
MULLEWA
GERALDTON
MINGENEW
MORAWA
THREE SPRINGS
CARNAMAH
PERENJORI
BUNTINE
WUBIN
DALWALLINU
MOORA
WALEBING
BALLIDU
KONDUT
OKLANNIE
KULJA
MOLLERIN
BEACON
CABBIN
BONNIE ROCK
CHERCURRIN
MUKINBUDIN
LAKE BROWN
WARRALAKIN
BULLFINCH
KOORDA
WONCAN HILLS
WYALKATCHEM
BINDI BINDI
DOWERIN
GOOMALLING
KUNUNOPPIN
NUNGARIN
WESTONIA
SOUTHERN CROSS
MOORINE ROCK
BURRACOPPIN
WALGOULAN
MERREDIN
KELLERBERRIN
NORTHAM
CUNDERDIN
PERTH
YORK
BRUCE ROCK
QUAIRADING
NAREMBEEN
BEVERLEY
CORRIGIN
KONDININ
KARLGARIN
WICKEPIN
NARROGIN
NEWDEGATE
BUNBURY
WAGIN
PINGRUP
KATANNING
ONGERUP
ALBANY
Scale of Miles

Map I.

REFERENCE
Localities heavily infested with Grasshoppers Spring 1936 shown thus.....
Grasshoppers numerous " " " "
Av rainfall for 7 months to end of July " "
Rainfall for 7 months to end of July 1936 " "
AJANA
NORTHAMPTON
MULLEWA
GERALDTON
MORAWA
MINGENEW
THREE SPRINGS
PERENJORI
CARNAMAH
BUNTINE
WUBIN
DALWALLINU
KALANNIE
KULJA
MOLLERIN
BEACON
BONNIE ROCK
BALLIDU
KONDUT
MOORA
WALEBING
GARBIN
KOORDA
WONGAN HILLS
BINDI BINDI
DOWERIN
GOOMALLING
WYALKATCHEM
KUNUNOPPIN
NUNGARIN
WESTONIA
BURRACOPPIN
MERREDIN
KELLERBERRIN
CUNDERDIN
NORTHAM
YORK
PERTH
QUAIRADING
BEVERLEY
BRUCE ROCK
NAREMBEEN
CORRIGIN
KONDININ
KARLGARIN
WICKEPIN
NARROGIN
NEWDEGATE
BUNBURY
WAGIN
PINGRUP
KATANNING
ONGERUP
ALBANY
RENCUBBIN
MUKINBUDIN
LAKE BROWN
WARRALAKIN
BULLFINCH
SOUTHERN CROSS
MOORINE ROCK
WALGOOLAN
Scale of Miles
0 25 50 75 100

Map II.


REFERENCE
Localities heavily infested with Grasshoppers Spring 1937 shown thus
Grasshoppers numerous
Av. rainfall for 7 months to end of July
Rainfall for 7 months to end of July 1937
AJANA
NORTHAMPTON
MULLEWA
GERALDTON
MORAWA
MINGENEW
PERENJORI
THREE SPRINGS
CARNAMAH
BUNTINE
WUBIN
DALWALLINU
KALANNIE
KULJA
MOLLERIN
BEACON
BONNIE ROCK
BALLIDU
KONDUT
MOORA
WALEBING
GABBIN
KENCUBBIN
MUKINBUDIN
LAKE BROWN
WARRALAKIN
KOORDA
WONGAN HILLS
WALLATCHEM
BULLFINCH
BINDI BINDI
DOWERIN
COOMALLING
KUNUNOPPIN
NUNGARIN
SOUTHERN CROSS
WESTONIA
MOORINE ROCK
BURRACOPPIN
WALGOOLAN
MERREDIN
CUNDERDIN
NORTHAM
KELLERBERRIN
PERTH
YORK
BRUCE ROCK
QUAIRADING
NAREMBEEN
BEVERLEY
CORRIGIN
KONDININ
KARLGARIN
WICKEPIN
NARROGIN
NEWDEGATE
BUNBURY
WAGIN
PINGRUP
KATANNING
ONGERUP
ALBANY
Scale of Miles
0 25 50 75 100

Map III.

The conditions governing the occurrence of our local plagues are then somewhat different to those which appear to be of primary importance in the Eastern States and South Australia, where *Chortoicetes terminifera* is the species chiefly in question. This insect approaches more nearly to the true locust in its habits and undertakes considerable migratory movements. Davidson (1936a) writes: "The development of the recent plague in South Australia is associated with the occurrence of rains markedly above the mean in parts of the pastoral zone during the warmer months of 1932 to 1934 . . . . The widespread occurrence of swarms throughout the wheat belt and the country south of it during the summer of 1934-35 was chiefly due to the eggs laid by winged swarms which invaded these areas from the north during the previous autumn."

As has been pointed out it is favourable conditions developing and causing a rise in the local population which seems to be chiefly responsible for our plagues rather than the result of invasions from outside. There is, however, much wore work to be done on this problem before all its aspects can be satisfactorily explained.

Soil and Vegetation.

The grasshopper zone corresponds roughly to that area of the State described by Prescott (1931) as "lateritic sand plain and mallee soils." However, there is such a diversity of soil types within this zone that such a description is of little use. The vegetation of this area he described as a mixture of mallee and Sclerophyll woodland and heath and Sclerophyll scrub. The light sandy soils are not suitable for grasshopper development and it is in the heavy soil supporting originally a growth of Salmon Gum (*Eucalyptus salmoniphloia*), Gimlet (*E. Salubris*) and Morrell (*E. longicornis*) that breeding chiefly takes place.

Natural Enemies.

Insects and Mites: A number of dipterous and hymenopterous parasites are found attacking various stages of the grasshopper, but accurate information as to their controlling influence is not available. One of the most promising dipterous forms is a Bombylid Fly (*Cyrtomorpha flavisentellaris* Rob.) whose yellowish larva feeds upon the eggs of the hoppers. This insect is widespread throughout the State and was found attacking eggs in most plague areas. Attempts have been made to introduce the Eastern States Scelionid parasite of *C. terminifera* into Western Australia in the hope that it might attack the eggs of *A. jungi*, but so far no success has been achieved. Small red mites (*Trombidi-idae*) have been noted attached to hoppers but they are of no known economic importance.

Birds and Mammals.

The Wild Turkey (*Eupodotis australis*)
The Straw-necked Ibis (*Threskiornis spinicollis*)
The Wood Swallow (*Artamus melanops*)
The Grey Butcher Bird (*Craticus torquatus*)
The Pied Butcher Bird (*C. nigrigularis*)
The Magpie (*Gymnorhina dorsalis*)
The Plover (*Zonifer tricolor*)
The Raven (*Corvus coronoides*)
The Brown Hawk (*Falco berigora*)
The Kestrel (*F. cenchroides*)

have all been noticed attacking grasshoppers in our own wheat belt. In many cases their stomachs were found to contain no other food and there is no doubt that at times birds play an important role in controlling insect populations.

A number of our native mammals, including the Pouched Mice or Dunnarts (*Sminthopsis spp.*), Phascogales (*Phascogale spp.*) belonging to the family Dasyuridae, include grasshoppers in their diet but the numbers of these mammals are now so depleted that they are of no economic importance.

CONTROL MEASURES.

Preventive Methods.

Timber in its natural state presents quite an effective barrier against grasshopper infestation and wholesale clearing and ring-barking for this reason should be deprecated, not to mention its effect upon the bird population and soil erosion. Every effort should be made to cultivate bare hard soil to render it unsuitable for egg laying. Known egg beds should be broken up as finely as possible to a depth of at least 2½ inches, thus fracturing the egg tubes and exposing the eggs to the elements and various natural enemies.

Cultural Methods.

The efficacy of ploughing and allied cultural methods as a means of grasshopper control has been viewed with suspicion by many authorities, but following the severe grasshopper plagues experienced in 1936 it was realised that drastic methods would have to be adopted to stem the advance of the pest, and a comprehensive scheme was undertaken by the Western Australian Government. Many thousands of acres were broken up by mouldboard an disc ploughs as well as by fixed tyne cultivators. Some of the operations were commenced under the dry summer conditions where the soil could be broken up, and contracts were continued up till June and July when the hoppers were hatching. Ample evidence of the effect of this work upon the resultant hopper population was gained by comparing the progeny arising from cultivated and non-cultivated fields and by estimating damage done to crops adjoining broken and non-broken country. Where in a few cases the work was done badly and clods and hard patches were left, a number of hoppers survived, but this only strengthened the contention that where the work is properly done effective control can be expected. Even after the grasshoppers had commenced hatching mouldboard and disc ploughs and sundercuts were used to advantage as they turned over the soil and buried most of the hoppers as well as the food supply of any which might have survived.

In the few cases brought to notice where cultivation was said to have been useless as a means of control, investigation showed that the work had been done late in the season when the hoppers were emerging and with fixed tyne cultivators. These machines do not turn the land over but merely break it up, and so although for pulverising the surface and destroying egg-beds they are very effective, they are less useful at a later stage when it is necessary to bury the young hoppers, and also the weeds which will supply the insects with the necessary energy to move from the fallowed ground.

The ability of young hoppers to live without food is remarkable, and under laboratory conditions they were found to survive for 10 days without nourishment, but upon moist blotting paper. After four days, however, they showed little activity, and it is unlikely that exposed to field conditions they would live more than a week or be able to travel far. Bearing this in mind, therefore, the importance of clean fallow, and where possible the advisability of working round and round a paddock so as to confine the hoppers to the centre, will be apparent.

BAITING AND SPRAYING.

Numerous field experiments have been conducted by the Government Entomologist with dusts, sprays and baits, and the following are recommended: -

Non-poisonous Sprays.

As a contact spray, Burford's household carbolic soap and Sunlight soap were found to be very effective against hoppers up to the third larval stage. Burford's soap was used at the rate of 2½ ozs. to the gallon and Sunlight soap at 2 ozs. to the gallon. Both should be mixed with hot water and applied while hot. The best time for spraying is early in the morning when the hoppers are sluggish.

Poison Spray.

Arsenite of Soda—1 lb.
Molasses—4 lbs.
Water—14 gallons.

This spray kills both by contact, due to the absorption of arsenic through the body integument of the insect, and also by the ingestion of sprayed foliage. It is particularly effective against young hoppers where green herbage is plentiful as is often the case early in the season.

Poison Bait.

Bran—25 lbs.
Arsenite of Soda—½ lb. (80% arsenious oxide).
Molasses—6 lbs.
Water—2½ gallons.

The above amount is sufficient to treat one acre. The arsenite of soda should be dissolved in water, likewise the molasses: the two should then be thoroughly mixed into the bran with sufficient additional water to make a moist crumbling mash. The amount of water required to bring this about may vary with different samples of bran but it is essential that the mixture is not allowed to become too wet, otherwise it will become lumpy and correct distribution will be impossible. It is best to thoroughly mix the ingredients and gradually add the water rather than pour in the estimated quantity all at once as an even mixture is difficult to obtain if the latter procedure is followed. Unless a broadcaster such as is described below is to be used the bait is best laid by hand, the mixture being thrown into the wind with a flick of the wrist so as to ensure that it will fall in fine particles.

During the campaign in the Narembeen Road Board area, it was demonstrated that the poison bait could be effectively distributed per medium of superspreaders. Two of these machines were brought into use on the property owned by Mr. W. N. Hedges. They were mounted on motor lorries and driven by a cog chain connected to the back wheel of the motor. The distribution of the bait by this means assured that it was scattered in the necessary fine particles, lumps being impossible. Mr. Hedges also devised a means of mechanically mixing the baiting ingredients.

This consisted of a circular drum or tank, which rotated about an axle fitted with a number of fixed arms or agitators. The tank was rotated by a belt attached to a small motor. By the use of these methods, much manual labour and manhandling of the baiting material is eliminated.

Danger to Stock.

Lumpy bait is a constant menace to stock just as long as the lumps remain. If the bait is laid carefully there is little or no danger to stock, but as a precaution it is advisable to remove stock from poisoned paddocks for a fortnight or three

weeks. Experiments conducted by the New South Wales Department of Agriculture have shown that where the spray is used, no danger to stock is incurred even if they are allowed immediate access to treated herbage.

Mixing Precautions.

When mixing arsenical solutions, care should be taken to keep the hands as free from the substance as possible, otherwise sores may result. Smearing the hands with grease of any kind before commencing operations will greatly minimise this danger. All receptacles should be carefully washed after having been used for mixing purposes.

ACKNOWLEDGMENTS.

I am considerably indebted to the Government Entomologist, Mr. L. J. Newman, for assistance and advice in the preparation of this article. My thanks are also due to the Commonwealth Meteorologist, Mr. A. Akeroyd, for placing at my disposal the data from which the accompanying maps were prepared, and to the Chief Draftsman, Lands Department, for assistance in preparing maps.

REFERENCES.

Davidson, J., 1934—Trans. Roy. Soc. of S. Aus., Vol. LVIII., p. 33, et seq.
„ 1936 *Ibid.* Vol. LX., p. 144.
„ 1936 a „ p. 150.
Newman, L. J., 1924—Jour. Dept. Agric., W.A., Vol. I. (2nd series), p. 199 et seq.
„ 1937—Jour. Dept. Agric., W.A., Vol. 14 (2nd series), p. 24.
Prescott, J. A., 1931—C.S.I.R. Aust. Bull. 52.
Stjostedt, Yngve, 1935—Revision der Australischen Acidiodeen 2 Monographie, Kungl. Svenska Vetenskapsakademiens Handlingar (Tredje serien) Band 15, No. 2.
Trumble, 1937—"Climatic Control of Agriculture in South Australia." Trans. Roy. Soc., S.A., Vol. LXI., p. 41.
Uvarov, 1928—Locusts and Grasshoppers. Imp. Bur. Ent. Lond., p. 168.

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THE CONTROL OF TOXIC PARALYSIS (BOTULISM) IN SHEEP AND CATTLE.

H. W. Bennetts, D.V.Sc.,
and
H. T. B. Hall, B.V.Sc.

INTRODUCTION.

Stockowners, unfortunately, are only too familiar with the manifestations of this disease which, because of its serious economic importance in this State has been the subject of much comment in this and other publications. The purpose of the present article is to give a brief account of experimental work carried out, during the past two years, by officers of the Stock Branch. The main object of this work has been the evolution of some means for the economic control of the disease. The experiments briefly summarised hereunder will be reported in detail elsewhere. The investigational work carried out by the Animal Nutrition Branch in connection with the cause and prevention of the depraved appetite which impels stock to eat rabbit and other carrion, and thus become affected with toxic paralysis, will not be described here.

The experimental work to be reviewed, with the exception of one experiment, was carried out on a farm at Meckering which had been leased by the Department for this and other purposes. The original project was drawn up in consultation with Dr. L. B. Bull, Chief of the Division of Animal Health and Animal Nutrition of the Council for Scientific and Industrial Research. The details of field work done in 1936 were planned and carried out by the then Senior Veterinary Surgeon, Mr. J. F. Filmer. Since August, 1936, the investigation has been carried out jointly by the two authors.

THE CAUSE OF THE DISEASE.

It has been known for many years that the cause of this disease is the toxin or poison of a germ (*Cl. botulinum*) which multiplies in decaying animal and plant material and there produces its toxin. Stock become affected as a result of the deliberate or accidental eating of material containing this toxin. There are, however, at least four kinds of germs which may produce the same disease. These germs are known scientifically as *Cl. botulinum* Type A, Type B, Type C, and Type D.

For reasons which will appear later it was very important to determine which was affecting stock in Western Australia. Bacteriological investigations carried out by one of us (H.W.B.) in the Perth Laboratory have indicated that only one, viz., *Cl. botulinum* Type C, is responsible for botulism of sheep and cattle in this State. It is probable that the same applies also to horses, but further work is necessary before this can be stated definitely.

THE SOURCE OF THE TOXIN.

Toxic paralysis of sheep and cattle almost always results from the ingestion of carrion, particularly rabbit carcases which are infected with the germ. Occasionally the source of infection may be chaff, hay, or other vegetation. More rarely it may result from the drinking of water containing the toxin, and in some instances it appears impossible to trace any source of toxin. Largely for this reason it was decided to determine, at Meckering, whether this disease would occur in sheep grazing on paddocks kept free from rabbits and carrion.

Early in the summer of 1936, a number of sheep were run on paddocks (90 and 53 acres) rabbit-netted and freed from live rabbits and carrion. Great difficulty was experienced in keeping these paddocks free from carrion as hawks, foxes, etc., continually introduced dead rabbits and the sheep frequently dug up old carcases which had been buried. For this reason, probably, results of this experiment were inconclusive. Several of the experimental sheep died of the disease and the source of the toxin was not established. A similar experiment was repeated on a smaller scale in 1937. Three contiguous rabbit-netted paddocks comprising in all some 5 acres were used. Little difficulty was experienced in keeping them free from carrion. The paddocks were used for retaining experimental sheep prior, and for some days subsequent, to experimental treatment. A supplementary ration of chaff was provided. The number of stock carried averaged from 20 to 30 throughout the summer. No deaths from toxic paralysis, other than those directly attributable to experimental treatment, occurred in these paddocks.

Rabbit Droppings.—During the summer months sheep are commonly observed to eat rabbit droppings and there is a popular belief that this habit may result in toxic paralysis. Experiments carried out at Meckering and at the Perth Laboratory in 1936 where sheep were drenched and fed with large quantities of rabbit droppings from different sources were attended by entirely negative results, thus indicating that rabbit droppings do not contain the germ poison.

THE TOXICITY OF RABBIT CARRION.

A large series of experiments were carried out in order to determine how poisonous infected carrion may be for sheep under different circumstances. It is known that the germ occurs naturally in certain soils and it is generally considered that carcases become infected with it when in contact with the soil. At the same time it has been shown that the germ may be present in the bowels of animals although not able to multiply and produce its toxin until after death. Experiments carried out by us at Meckering this year showed that some rabbits may carry the germ in their bowels. At the same time it appears probable that the germ generally gains access to rabbit carrion from soil contamination after death. For the experimental work in 1936, in order to make sure that rabbit carrion to be tested for poisonous properties was actually infected with the germ, freshly killed rabbits were inoculated (per rectum) with broth cultures of *Cl. botulinum* Type C. They were then placed on the ground in a small netted enclosure, thus being protected from the depredations of animals and birds but not of insects. Such carcases will be referred to as *artificially infected carrion.* The carcases were tested at intervals for toxicity by drenching weighed amounts of minced muscle, bone, etc., to experimental sheep which had not been exposed to other sources of infection. Filmer's work indicated that the muscle (the part of the carcase generally relished by sheep) attained its maximum toxicity at 3 to 5 days when as little as 3 gm. (one-ninth of an ounce) of the material would kill a sheep. He found, however, that the toxicity diminished greatly with desiccation so that as much as 5 gm. of 26-day old carrion produced no symptoms in sheep. Other observations, however, indicated that old and desiccated rabbit carrion under normal field conditions could be much more highly toxic than this. On the other hand, observations both in 1936 and 1937, indicated that sheep showing a markedly depraved appetite do not readily eat rabbit carrion before it is 8 to 10 days old.

A long series of experiments with both artificially and naturally infected carrion (carcases not inoculated with the germ but exposed in the same netted enclosure referred to previously) were carried out during the past summer in order to throw some further light on this apparent anomaly. Results obtained were somewhat at variance with those of the previous season, notably in the demonstra-

tion that the toxicity of artificially infected carrion may remain at a high level for a longer period under similar experimental conditions (in one experiment 5 gm. of muscle from a 36-day old artificially infected carcase killed an experimental sheep). The present position may be summarised:—

(a) The degree of toxicity of rabbit carrion may vary considerably under apparently similar conditions. There are indications that summer temperatures favour the development of toxicity.

(b) It appears that in general, bones are at no stage as highly toxic as the remainder of the carcase. It had been considered possible that bones might retain their toxicity for a longer period than the softer parts of the carcase but experimental evidence indicates that such is not the case.

(c) Carrion shaded from sunlight retained its initial degree of toxicity for a much longer period than carrion freely exposed. It would appear probable, therefore, that carrion shaded by stubbles, etc., or buried, may remain highly toxic for considerable periods. One of us (H.W.B.) in 1928 investigated an outbreak of toxic paralysis in sheep which resulted from the eating of rabbit carcases which had been buried in warrens for six months previously, and in 1937 it was shown, experimentally, that rabbit carrion exposed in the open for at least seven months may be still dangerous to stock (50 gm. were fatal to sheep).

(d) Two experiments (1937) in which rabbit carcases were left in contact with soil known to have been heavily contaminated with the germ *Cl. botulinum* indicated that carrion does not necessarily become toxic even under such apparently favourable conditions. If, however, it does become infected the period of maximum toxicity may occur later than in the case of artificially infected carrion (4 to 5 days) and may coincide with the time when carrion first becomes palatable to sheep (8 to 10 days).

These experiments further showed that the maximum toxicity of natural carrion may be of the same order as that of artificially infected carrion.

The practical importance of these experiments is this:—Under ordinary field conditions *it is quite probable that stock may ingest rabbit carrion so highly poisonous that the consumption of only one-sixth of an ounce* (5 *gm.*) *will kill a sheep.* Although the toxicity decreases with age carrion at least 6 to 7 months old may be still dangerous to stock, particularly if buried or otherwise protected from sunlight and drying.

CONTAMINATED WATER AS A SOURCE OF TOXIC PARALYSIS.

Several outbreaks of toxic paralysis have been brought under our notice in which the field evidence strongly pointed to water, containing carrion, as being the source of the disease. The laboratory findings in these cases have not been conclusive, it being difficult to demonstrate the presence of minute amounts of toxin.

Experiments were carried out at Meckering in 1936 and 1937. It was found that water could be made toxic by introducing infected carrion, this being effected by placing a rabbit carcase in a 40-gallon drum of water. As little as eight fluid ounces of such water drenched to a sheep may cause death. Filmer demonstrated that the addition of quicklime—at the rate of 2 lbs. to 40 gallons—destroyed the toxin within several hours, and that such water was not unpalatable or harmful to sheep. Further observations by us indicate that it is not advisable to appreciably lower this concentration, and that it is unlikely that water saturated with quicklime will become dangerous to stock if it is subsequently contaminated with infected carrion.

PREVENTION BY VACCINATION.

As a result of experimental work carried out during the last two seasons it has been proved conclusively that inoculation with a vaccine, "botulinus toxoid," constitutes an effective, safe, and economical method for the prevention of the disease in sheep and cattle. These experiments will be dealt with only very briefly here.

(1) 1935-36 *Experiments and Field Trials.*—Dr. L. B. Bull very kindly arranged for the preparation of the toxoid (Type C and D) in the Laboratories of the Council. The experimental tests were carried out by Mr. Filmer at Meckering. A number of experimental sheep were inoculated with the vaccine, receiving a dose of 1 c.c. followed 4½ months later by a second dose of 5 c.c. They were tested one to two months later by drenching with minced rabbit carrion (artificially infected with *Cl. botulinum* Type C). Three grammes of this material killed control (unvaccinated) sheep, whereas inoculated sheep which received 100 gm. showed no ill effects. This indicated that vaccination would protect sheep against at least 30 times the smallest dose of toxin which would kill uninoculated animals (= M.L.D., viz. minimal lethal dose). A further test indicated that protection was maintained to a high degree for at least 4½ months after the second inoculation.

In another experiment artificially infected rabbit carcases were placed in a paddock accessible to 10 vaccinated and 10 unvaccinated sheep. Within 8 days seven of the unvaccinated sheep were dead and one other showed signs of toxic paralysis. No vaccinated sheep showed any symptoms, though a number of them were seen eating carrion.

Field trials were also carried out. About 100 sheep were vaccinated on each of 19 farms where losses from toxic paralysis had been known to occur. The first dose of toxoid (1 c.c.) was given about the end of October, 1935, and the second dose (5 c.c.) about the middle of January, 1936.

On five of the farms the vaccine had a significant effect of reducing the mortality from the disease (mortality 1.3 per cent. in 461 vaccinated; 13.0 per cent. in 1,412 controls). On the other properties very few deaths occurred in either section of the flocks.

The results of these experiments showed very clearly that the toxoid as given confers on sheep a very definite protection against doses of toxin many times the M.L.D. and led to departmental advice that sheepowners apply for toxoid for trial the following season. The wisdom of this early imparting of information was amply confirmed by results obtained the following season.

(2) 1936-37. *Experiments and Field Trials.*—The toxoid used was prepared by the Commonwealth Serum Laboratories, Melbourne, and is now supplied by them to the Department as required.

Experimental tests of the efficacy of this toxoid were carried out but the resistance of vaccinated animals was determined by a different method to that used previously. Instead of drenching the experimental animals with minced infected carrion they were inoculated with solutions of the dried standardised toxin of the germ (*Cl. botulinum* Type C) produced in the Perth Laboratory.

Sheep Experiments at Meckering.—Early in 1937, 36 sheep were inoculated with two doses of toxoid, the first dose being 1 c.c. and the second 5 c.c. They were divided into equal groups which received the first and second dose at different intervals, viz., 1 month, 2 months, and 4 months. The groups were tested at one time) in each case one month after the second dose of toxoid by inoculating with graded doses of the germ toxin. The highest dose tested was 5,000 M.L.D. (M.L.D. = smallest dose which will kill a sheep). None of those so tested, *i.e.*, 6 sheep, showed any sign of toxic paralysis. It might be pointed out here that a sheep would need to eat at least 50 of the most highly toxic rabbit carcases inves-

tigated to obtain 5,000 M.L.D. of toxin. It would appear impossible for a sheep to ingest sufficient toxic carrion to break down so solid an immunity. The eating of occasional toxic carcases would tend only to further strengthen the animal's resistance.

There were indications, however, that the response in the experimental group which received their two doses of toxoid at only one month's interval were somewhat irregular. It is recommended, therefore, that at least two months should elapse between the administration of the two inoculations of toxoid.

Experiments carried out to determine the duration of immunity indicate that although some animals are highly resistant to toxin up to 16 months after vaccination, others may lose a considerable degree of the immunity within 12 months. It was demonstrated too that the immunity can be strongly reinforced by the administration of one "refreshing" dose (5 c.c.) of toxoid. For this reason, and because it is desirable to maintain a high degree of resistance in flocks which have access to abundant carrion it is recommended that sheep *which have been inoculated the previous season* should receive one 5 c.c. dose of toxoid at the beginning (November-December) of the following season.

Field Trials—Sheep, 1937.—Towards the end of 1936 some 60,000 sheep were inoculated with C.S.L. botulinus toxoid. The properties concerned were spread throughout the agricultural areas. Vaccination was carried out by the sheepowners themselves following demonstrations by officers of this Department. At the advent of winter 95 properties were visited by one of us (H.T.B.H.) and pertinent information obtained. In most cases all sheep were inoculated, no controls being kept. On four properties, however, somewhat significant results were obtained:—vaccinated sheep 2,200, deaths 0; controls 867, deaths 46 = 5 per cent. (on one property 23 ex 100 controls died). From a total of 53,620 sheep vaccinated on 95 properties only two deaths from toxic paralysis were reported.

Although the losses in districts visited were much lighter generally this season, the reported total incidence of the disease on the 95 properties visited was 13.2 per cent. for 1935 and 10.7 per cent. for 1936. It appears reasonable to consider, therefore, that the toxoid did have a definite influence in controlling the disease during the 1937 season.

Cattle Experiments at Beverley.—The details of this experiment have been reported previously in this Journal.*

In January, 1937, six cattle were inoculated with 2 c.c. of botulinus toxoid and two months later with 10 c.c. One month later they were tested for immunity by inoculating with solutions of desiccated toxin given in graded doses. All survived the test including two which received the highest dose—500 M.L.D.

Field Trial—Cattle, 1936-37.—Seventy-five cattle on eight properties were inoculated with toxoid, vaccination being completed just prior to December, 1936. The two doses were larger than those used and recommended by Dr. Bull. There were no deaths amongst the 75 inoculated cattle, whereas 6 ex 73 controls = 8.2 per cent. died of toxic paralysis.

NOTE.

Reference was made earlier to the importance of determining which type of the germ *Cl. botulinum* causes toxic paralysis in this State. The significance is this—the toxiod now in use is prepared from *Cl. botulinum* Type C and will give adequate protection only against this type. We have, however, no indication that there is any necessity to protect against any of the other types.

SUMMARY.

(i) Toxic paralysis (botulism) of sheep and cattle in Western Australia results from the ingestion of material, generally carrion, containing the toxin of the germ *Cl. botulinum* Type C.

* Bennetts, H. W.: Toxic Paralysis (Botulism) of Cattle—Prevention now possible. Jour. Dept. Agric. W.A. 14 (2): 127, 1937.

(ii) Experimental evidence indicates that rabbit carrion, probably the commonest source of toxin, may be very highly poisonous in the stage at which it is relished by sheep. The ingestion of an amount as small as one-sixth to one-ninth of an ounce may prove fatal. The influence of several factors on the toxicity of such carrion is discussed.

(iii) Vaccination with botulinus toxoid affords a very high degree of resistance to the disease in both sheep and cattle as has been verified by experiments and field trials. It is recommended that at least two months elapse between the first and second inoculations with toxoid. The doses recommended are sheep 1 c.c. and 5 c.c., cattle 2 c.c. and 10 c.c.

Animals previously vaccinated in this manner should receive one "refreshing" dose of toxoid, in amount equivalent to the second dose, at the beginning of each following season.

THE DENMARK WASTING DISEASE.

Cobalt Status of some West Australian soils.

R. J. Harvey.*

INTRODUCTION.

The efficacy of very small doses of cobalt salts in the treatment of the Wasting Disease has now been thoroughly established. In South Australia and in New Zealand treatment of similar stock ailments with drenches and licks containing cobalt has been equally successful. The therapeutical potency of this element, however, does not, in itself justify the conclusion that the presence of cobalt in the animal's normal diet is essential to normal health and growth, and a logical step which suggested itself in the elucidation of this question was the examination of soils and pastures from affected districts, with a view to determining whether there existed, in these areas, any correlation between the cobalt status of soils and pastures and the incidence of the disease. In addition, in the event of the determination of soil cobalt having some value as an indication of the character of virgin country, with respect to the disease, the establishment of the cobalt status of healthy and unhealthy soils is desirable for purposes of reference.

Some 12 pasture samples were analysed for cobalt content as a corollary to the examination of the soils. As the number of samples examined is inadequate as a basis for comprehensive discussion the results are given in Appendix A.

EXPERIMENTAL.

The method used for the determination of cobalt in soils was that of Kidson, Askew and Dixon† (1). In view of the conclusions of New Zealand workers (Grange and Taylor) (2) that the surface soils appeared to be of most importance in determining the character of the soil with respect to the incidence of a similar stock disease (bush sickness) the surface samples of the soil profiles selected for examination were analysed wherever possible.

COBALT STATUS OF DENMARK SOILS.

The surface soils from type samples collected during the soil survey of the Denmark district have been examined and the results are grouped under soil types in Table I.

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* Chemist attached to animal nutrition investigations. † Numbers in brackets refer to literature cited.

TABLE 1.

Cobalt Status of Denmark Soils.

Serial No.	Soil Description.	Location.	Depth of Sampling.	Cobalt (Co) parts per million in Air-dry Soil.
			inches.	
3938	Wakundup gravelly sand—grey phase ...	463	0–2	0·5
3994		455	0–5	0·5
4004		495	0–2	1·1
4112	Vegetation—mainly karri	502	0–3	0·5
4202		574	0–5	0·5
	Average	...	...	0·6
3928	Wakundup gravelly sand—brown phase ...	343	0–1	0·5
4026		461	0–1	0·75
4058	Vegetation—karri and sheoak	507	0–2	1·5
4121		470	0–5	0·5
	Average	...	...	0·8
3961	Wakundup very gravelly sand	720	0–4	0·7
3985	Vegetation—karri and sheoak	468	5–14	1·5
4052		583	0–3	30·0
4096	Alluvial and wash soils	496	0–3	4·2
4214	Brown silty sandy loam	561	0–3	19·0
4393	Vegetation—mainly redgum and jarrah ...	384	0–4	4·5
4399		346	0–3	5·6
4413		376	0–6	1·6
	Average	...	...	12·1
3946	Scotsdale gravelly loam	453	0–9	2·0
4005	Reddish brown sandy loam	455	0–9	2·4
4044	Vegetation—mainly karri	512	0–9	3·5
4164		344	0–4	10·0
	Average	...	...	4·5
4078	Scotsdale gravelly sand	524	0–9	5·0
4219	Vegetation—mainly karri	497	0–4	0·15
4086		480	0–3	0·6
4272	Kordabup sand. Variable hardpan. Grey sand	721	0–6	0·2
4293	Vegetation—jarrah and redgum	478	0–4	0·4
4303		485	0–6	0·2
	Average	...	...	0·4
3968	Kordabup sand, well defined hardpan.	576	0–6	0·3
3979	Greyish black sand	561	0–6	0·5
4192	Vegetation—stunted jarrah and sheoak ...	5514	0–8	0·5
4239		669	0–5	0·1
	Average	...	...	0·35

TABLE 1—*continued.*

Cobalt Status of Denmark Soils—continued.

Serial No.	Soil Description.	Location.	Depth of Sampling.	Cobalt (Co) parts per million in Air-dry Soil.
			inches.	
4034	Plantagenet peaty sand	480	0–1	0·5
4136		471	0–1	0·2
4174		556	0–1	0·3
4246	Vegetation—stunted jarrah and blackboy ...	4249	0–6	0·3
4286		496	0–1	0·2
	Average	...	..	0·3
4018	Kwilalup sand; grey sand	502	0–4	0·5
4070		506	0–3	0·4
4144	Vegetation—Stunted jarrah and banksia ...	470	0–7	0·5
4230		457	0–7	0·5
	Average	...	...	0·5
4260	Willbay sand. Grey black sand	4249	0–4	0·1
4268	Vegetation—jarrah, redgum and sheoak ...	4238	0–6	0·25
3936	Swamp soils; grey clay or loams ...	432	0–10	3·2
3974		577	9–18	2·0
4011	Vegetation—mainly bayonet grass and file	455	0–9	1·5
4210	grass	Boundary between 573 & 574	0–9	3·2
	Average	...	...	2·5
3952	Laterite boulder areas. Grey sandy gravel	Boundary between 457 & 698	0–4	1·0
4150	Vegetation—jarrah, redgum and banksia	492	0–4	1·2
4313		464	0–4	0·7
	Average	...	...	1·0
4129	Koorrabup gravelly sand; grey sand	470	0–1	0·5
4158		2110	0–2	1·5
4182	Vegetation—jarrah, redgum and banksia	5514	0–2	0·6
4386		378	0–2	1·2
	Average	...	...	1·0
4221	Unnamed sandy loam ... ... Vegetation—jarrah, redgum and banksia ...	Boundary between 575 & 576	0–1	0·5
4370	Koorundurup gravelly loam. Dark chocolate loam Vegetation—karri and sheoak	428	0–3	32·0
4378	Koorundurup very gravelly sand	428	0–5	2·5
4405	Vegetation—karri and sheoak	346	6–30	1·0

COBALT STATUS OF PRESUMABLY HEALTHY SOILS.

In order to determine the cobalt status of normal soils a number of soil samples was examined from districts in which no stock ailment resembling the Wasting Disease had been known to occur. The results are grouped according to locality in Table II.

TABLE 2.

Cobalt Status of Presumably Healthy Soils.

Serial No.	Locality and Description.	Depth of Sampling.	Cobalt (Co) parts per million in Air-dry Soil.
		inches.	
336	Gosnells: Orange orchard—grey sand with gravel ...	0–10	3·3
341	Maddington: Orange orchard—dark grey sand and gravel	0–12	9·0
313	Near Chapman Siding (Geraldton)—pale brown sand ...	0–2½	0·8
317	Near Chapman Siding—grey brown loam	0–2	8·5
321	Near Chapman Siding—dull brown sand	0–2	3·0
328	Near Chapman Siding—grey brown sand	0–2	4·5
	Average	...	4·2
346	East Broomehill—Yate flat, dark	0–1	7·5
349	Pallinup—York gum and jam under wheat; grey brown gritty loam	0–5	5·5
353	Pallinup—York gum and morrel; cleared fertile paddock—brown clay loam	0–5	14·0
356	Adjacent to 353—Brown crumbly loam	0–4	15·0
360	Pallinup—Morrel; good lucerne country—strip of grey gritty loam	0–2	4·5
361	Subsoil of 360—Grey gritty clay	2–10	5·5
364	Gnowangerup—Patch of grey crumbly clay	0–5	10·0
367	Gnowangerup—Morrel country—grey brown gritty sandy loam	0–3	9·0
373	Gnowangerup—Poor mallee country; grey gritty sand	0–7	0·5
376	Gnowangerup—Salmon gums; excellent country adjacent—grey brown loam	0–7	10·0
380	Gnowangerup—White gum, manna gum, sheoak; poor country—grey gritty sand	0–12	0·5
382	Gnowangerup—White gum and mallee; very poor country grey gritty clay	0–10	2·0
384	Gnowangerup—Salmon gums; grey sandy loam ...	0–4	8·5
388	Kebaringup—Moort; good grass country—dark brown crumbly clay	0–6	25·0
397	Corunup—Pocket of York gum, jam and morrel; very fertile wheat country—grey brown loam	0–3	9·0
	Average	...	8·4
2182	Deepdale, Toodyay—York gum; brown gritty loamy sand	0–12	26·0
2184	Deepdale, Toodyay—York gum; brown sandy loam...	0–7	28·0
1800	Bridgetown: Apple orchard—Red gum country; chocolate brown loam	0–12	40·0

DISCUSSION OF RESULTS.

It is evident that the soils of the Denmark area are generally low in cobalt in comparison with the soils from other districts and it would appear that this condition is quite widespread within the Denmark district. The results, too, suggest that only a limited number of soil types within the Denmark district, Scotsdale gravelly sand and loam, alluvial and wash soils, swamp soils, and the Koorundurup loam has a cobalt status of the order of that of soils from presumably healthy districts.

Table III. illustrates the distribution of samples according to cobalt content in ranges of cobalt (as p.p.m. Co.) in the air dry soil. Group 1A includes the virtually non-agricultural soils of the Plantagenet, Kwilalup, and Willbay series.

Group 1B includes soils of the Wakundup, Kordabup, and Koorrabup series, the Koorundurup very gravelly sand, the unnamed sandy loam and the laterite boulder areas which are largely developed for pasture purposes.

Group 2 includes the Scotsdale series, Koorundurup gravelly loam, alluvial and wash soils and swamp soils which are largely developed for pasture purposes.

Group 3 includes presumably healthy soils from other districts.

TABLE 3.

Cobalt Distribution.

Group.	Number of Samples giving results falling within ranges—				
	Less than 1·0 p.p.m. Co.	1·0–2·0 p.p.m. Co.	2·0–4·0 p.p.m. Co.	4·0–10·0 p.p.m. Co.	Above 10 p.p.m. Co.
1A	11	...	...	...	...
1B	20	8	1	...	...
2	1	2	6	4	4
3	3	...	3	10	8

As several soil types generally occur on any one holding it is difficult to correlate soil type and the incidence of the wasting disease. It is found, however, that the disease appears to be generally associated with certain soil types included in Group 1 of Table III., especially the Wakundup and Kordabup series and the unnamed sandy loam, while those of Group 2, with the exception of the swamp soils, are of comparatively limited distribution (see Denmark Soil Survey Map) (3), and never predominate on affected holdings.

The gradations in soil cobalt are in general in accordance with the degree of "soundness" of the different holdings and appear to give some measure of the relative influence of an individual soil type on the character of a holding on which several soil tyes occur.

Kidson (4) working on New Zealand soils has shown that although soils affected with bush sickness have comparatively low cobalt contents, a number of soils from other parts of New Zealand, where no such stock ailments are known, have been found to be very low in cobalt. Further, at Morton Mains, Southland, New Zealand, where cobalt supplements have been used with good results, the cobalt content of the soils examined varies from 2.8 to 8.3 parts per million, by no means a very low figure. Attempts to explain these anomalies on the basis of availability were unsuccessful and Kidson concludes "that the determination of the cobalt content of the soil is not sufficiently satisfactory as a guide to the necessity for using cobalt supplements for stock."

The cobalt survey of West Australian soils has not been sufficiently comprehensive to justify a decision as to the value of soil cobalt determinations as a guide

to "soundness," but the results suggest that the differences in the cobalt contents of soils from affected and unaffected country are more marked in this State, and a knowledge of the cobalt content is likely to be useful in the evaluation of the possible liability of virgin country to the disease.

CONCLUSION.

The soils of the Denmark district, and especially those soil types predominating in affected holdings, are generally low in cobalt in comparison with presumably healthy soils. This conclusion supports the suggestion that a deficiency of cobalt in the diet of stock affected with wasting disease is responsible for the ailment.

The widespread distribution within the Denmark area of soil types of low cobalt status would suggest that even on holdings where no actual instance of the wasting disease has been known, stock might benefit from the addition of a cobalt supplement to their normal diet. The trial of cobalt supplements, with a view to stock improvement on these holdings, would therefore seem to be well worth while. Indeed, sandy soils generally appear to be deficient in cobalt, and, if the cobalt content may be taken as an indication of the mineral status of such soils generally, the trial of mineral supplements, such as limonite licks, with stock confined to sandy soils would be well advised.

SUMMARY.

1. A number of soils from various districts in Western Australia has been examined for cobalt.

2. A marked difference is apparent between the soils of the Denmark district and those of districts unaffected by the wasting disease or any similar stock ailment.

3. Within the Denmark district the cobalt status of an individual soil type is, in general, fairly uniform and soil types of low cobalt status predominate in unhealthy holdings.

4. It is suggested that soil cobalt determinations may be of some value as a guide to "soundness" in Western Australia.

5. The results of the cobalt survey are considered to support the suggestion that a dietary deficiency of cobalt is the cause of disease.

6. The trial of cobalt supplements is recommended with a view to stock improvement on presumably healthy holdings within the Denmark district.

7. It is suggested that the supplementary feeding of minerals may prove of value with stock confined to grazing on sandy soils elsewhere in the State.

ACKNOWLEDGMENTS.

The field notes concerning the Denmark soils have been taken from reports by Messrs. J. S. Hosking and G. H. Burvill. The descriptions of other soils are those of Dr. L. J. H. Teakle, to whom my thanks are tendered for many valuable suggestions with regard to the preparation of this paper. The author is indebted to the Department of Lands and Surveys for the preparation of the map included in this paper.

REFERENCES.

1. E. B. Kidson, H. O. Askew, and J. K. Dixon—"The Colorimetric Determination of Cobalt in Soil and Animal Organs"; N.Z. J. Sci. & Tech., 99, p. 473, 1932-33.

2. Grange L. K., and Taylor N. H.—"The occurrence of bush sickness on the volcanic soils of the North Island." N.Z. D.S.I.R., Bull. 32, part 2, 1932.

3. Hosking, J. S., and Burvill, G. H.—"Soil Survey of the Denmark District." J. Coun. Sci. Ind. Res. (Aust.) (in press).

4. Kidson, E. B.—"Cobalt Status of New Zealand Soils." N.Z. J. Sci. & Tech. 18, 694-707, 1937.

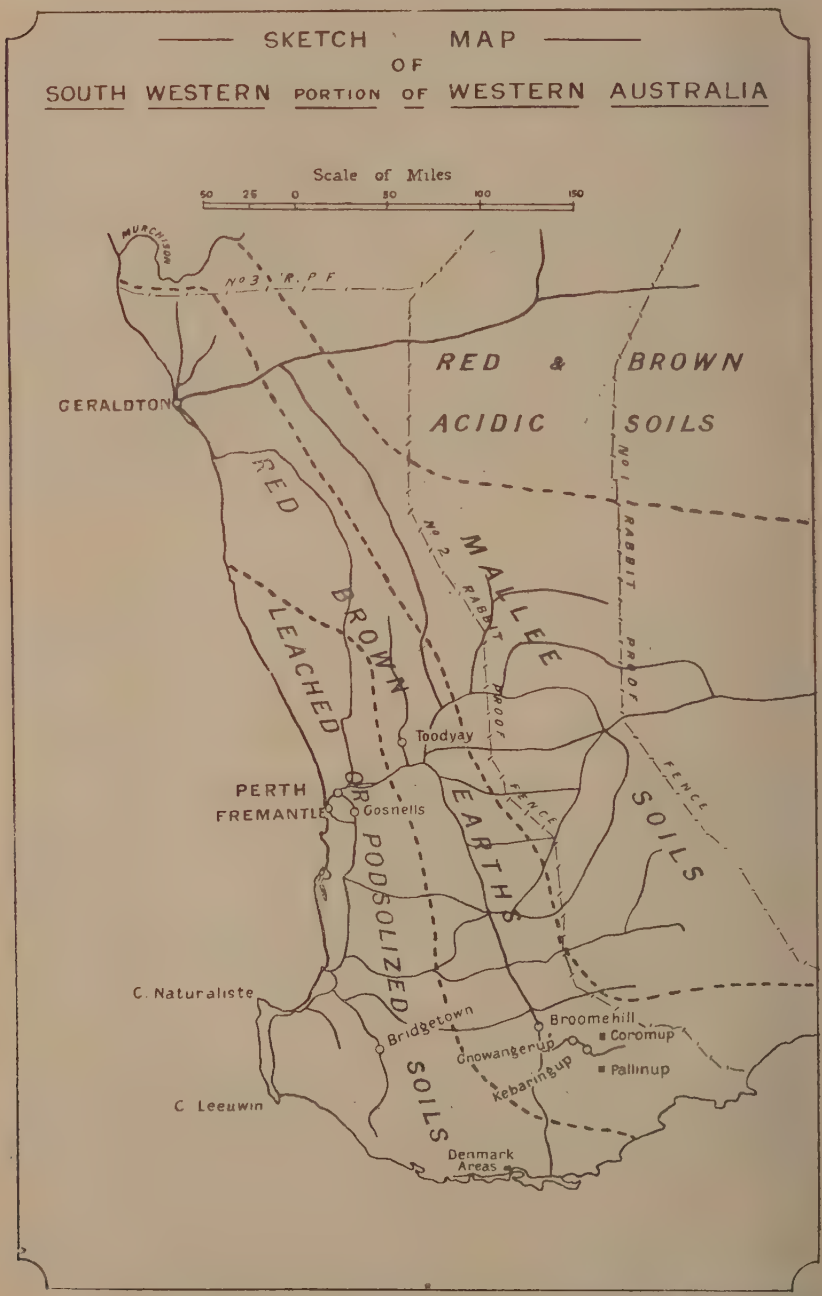


Fig. 1.—Sketch map of the South-Western portion of Western Australia showing the major soil zones, the railway system and principal centres from which samples used in this study were obtained.

APPENDIX A.—COBALT STATUS OF PASTURES.

R. J. HARVEY.

From time to time in the literature some reference has been made to the presence of traces of cobalt in plant materials, but until recently it has been regarded as of no dietetic significance. The demonstration of the value of cobalt salts in the treatment of the Denmark Wasting Disease indicated that the examination of pastures from healthy and unhealthy districts might at least provide information regarding the intake of cobalt by the grazing animal. It must be remembered, however, that the plant material proper does not necessarily provide the only source of elements required for normal health in grazing stock and that the soil ingested during feeding may conceivably contribute the major portion. This is especially true of so-called minor elements of which only very small amounts are required.

Experimental.—In sampling pasture material care was taken to avoid as far as possible contamination with soil, and although most of the samples examined were mainly clovers no attempt was made to collect any single plant species.

The samples were dried, ashed in silica dishes, the ash extracted with hydrochloric acid, and silica, phosphorus and calcium removed successively from the extract. Finally, the sulphides of iron, cobalt, nickel, etc., were precipitated and after elimination of the iron, the cobalt was determined colorimetrically using nitroso-R-salt.

This method of separation was thoroughly checked and gave satisfactory recoveries of 0.10 to 0.005 milligrams of cobalt added to synthetic solutions of plant ash and of similar amounts of cobalt added to plant material.

COBALT STATUS OF PASTURES.

Denmark Pastures.

Sample No.	Sampling Date.	Farmer.	Location Numbers.	Character of Pasture.	Description.	Cobalt—parts per million Co.
1	....	Denmark District		Healthy	Aggregate	0·30
2	16–10–36	Denmark Town site		do.	....	0·15
3	16–10–36	J. Paterson	377	do.	....	0·07
4	14–6–37	Fred Bayley	385 and 386	do.	....	0·035
5	....	Denmark District		Unhealthy	Aggregate	Less than 0·03
6	16–10–36	J. Murray	451	do.	....	Less than 0·05
7	16–10–36	N. Kingdon	450	do.	....	0·07
8	14–6–37	F. C. Smith	552	do.	....	0·05
		G. Hard	446			
		Average	....	....	....	0·08*

Pastures from other Districts from which the Disease is not Reported.

					District.	
9	7–8–37	Avondale Research Station	....	....	Beverley	0·15
10	1–6–37	Harding	15	....	Brunswick	0·03
11	1–6–37	J. Smith and Sons	2712	....	Waterloo....	0·18
12	1–6–37	R. A. Clarke	1	....	Roelands....	0·16
		Average	....	....	....	0·13

* Samples 5 and 6 are not included in this average.

Discussion.—The results for the pasture samples examined show a wide variation irrespective of the character of the country and any attempt to correlate the cobalt status of the pastures and the incidence of the disease would appear to require a great deal of analytical data. It is of interest to note, however, that a sheep's daily intake of cobalt from pasture of cobalt status equal to the average value for healthy pastures would, on the assumption of 2 lbs. dry matter intake, be about 0.12 milligram, which is of the order of the minimum optimum curative daily dose 0.10 mgm. as determined by Filmer and Underwood (1) for sheep affected with Wasting Disease.

(1) Filmer, J. F., and Underwood, E. J. "Enzootic Marasmus: Further data concerning the potency of Cobalt as a curative and prophylactic agent." Aust. Vet. Jour. 13: 57-64, 1937.

SOIL DRIFT RECLAMATION BY MEANS OF LUPINS.

By G. L. Throssell,
Agricultural Adviser

At this time of the year it is opportune to draw attention to the fact that something should be done, between now and next seeding, to check the soil drift in our agricultural areas. There is no denying the fact that soil drift, or to use the more general expression, wind erosion, is yearly becoming worse in some areas. In these areas whole fields are rapidly being converted into barren wastes; and dust storms are annually becoming more frequent and intense. Good soil is being moved by the action of the wind from one paddock to another, and from one farm into the next. The fertile soil in some instances is being removed and a much less fertile subsoil is being exposed. In other cases light sandy soils are drifting and covering up richer and better soils. Fences are being covered; dams and water troughs filled in with drift; and water courses, rivers and roads are being obstructed. The economic loss to the farmer and the State is very considerable.

The causes of soil drift are many, but the chief factors in our agricultural districts are the long dry summers, during which the surface of the land is denuded of vegetation and protective covering. This has been accentuated during recent years by the winter rainfall being below the average; the depredations of rabbits; overstocking; and others factors such as clearing, fires, and farming methods employing a short rotation, including frequent bare fallows. The natural protective covering of vegetation and herbage has disappeared and on those soils which naturally have a tendency to drift the onset of strong winds has soon exacted its toll.

The purpose of this article is to describe how two cases of soil drift were successfully reclaimed, and thereby it is hoped to encourage others faced with the same problem to tackle theirs this coming year. In both cases the drift was controlled by growing the local blue lupin (*Lupinus varius*) mixed with a cereal crop.

The first case was at Yandanooka which is situated 214 miles from Perth, on the Midland Railway, and which has an average annual rainfall of 18.29 inches. The other instance was at Irwin, also on the Midland Railway, but 40 miles further north and near Dongarra, which has an average annual rainfall of 18.89 inches.

In the summer of 1933-34, when visiting the property of Mr. F. W. Benham, Yandanooka, the writer saw a small paddock on the top of a hill which had been reclaimed by growing the local blue lupin. The soil was a light sandy loam, and after it was cleared strong south-west winds started a drift. Mr. Benham reports that in April, 1932, he ploughed the paddock, and planted a bushel of oats with 90 lbs. of superphosphate per acre and then broadcast 4 lbs. of lupin seed per acre on the surface. He allowed the subsequent oat crop to shed, and then only grazed the stubble very lightly in the late autumn when the danger of drift was less. The initial stand of lupins produced sufficient seed to provide a very even crop in the second year. Since then he has had no further trouble from drift on this paddock and, in fact, has converted what undoubtedly would have become a menace to his homestead and farm, into one of his most useful grazing paddocks.

The second case was on the property of Mrs. W. B. Mitchell, "The Grange," Irwin.* The consensus of opinion was that the drift here had got out of hand and could never be reclaimed. In view of the success achieved by Mr.

* The soil drift here was well known along the Geraldton to Perth road, because it completely obstructed the traffic.

Benham at Yandanooka, the manager of "The Grange," Mr. Keith B. Mitchell, decided to adopt a similar method this year, and the success which has rewarded his efforts should undoubtedly encourage others faced with a similar problem.

The drift at Irwin commenced in January, 1935, and was mainly caused by sheep continually camping in the one place, on the side of a hill, which had no protection from the easterly and south-westerly winds. The country being a red sandy soil, which originally grew black wattle, became very loose, and by the end of the summer it was estimated that the drift covered an area of two acres. The first rains brought up a green shoot of capeweed, but this was not sufficient to check the drift, which soon covered any plants which grew.

THE SITE FROM WHICH THE DRIFT COMMENCED.

Surface soil to a depth of at least a foot has been blown away and transported nearly a quarter of a mile. The trees in the background indicate the position of the main Geraldton to Perth road, which was blocked. Note the poor growth of barley and oats, and fairly good growth of lupins on the apparently sterile subsoil which was exposed.

L. J. H. Teakle, Photo.

At the end of the 1935-36 summer, the drift had covered approximately ten acres. Again a green shoot came through with the first rains and would have checked the movement of the soil had not a dry spell occurred which killed all the young plants. Soil drifted continuously through the winter no matter how much rain fell and within a few hours after the rain the slightest wind would create a dust. To make the road passable, the Main Roads Board erected a brush fence 3 feet 6 inches high, but this was covered in a few months and the drift extended across the road blocked the traffic, and altogether extended a distance of 500 yards or more. At the end of last summer the drift had covered an area of about fifty acres, forty acres being covered in 12 months. An average of about a foot of soil was removed from an area of twenty acres, while in some places where the soil was very loose it had been blown away to a depth of two feet.

In order to clear the road, the Main Roads Board graded back the drift sand from the road and to do so moved a very considerable quantity of soil.

The paddock on the north side of the road was typical york gum country. Fourteen acres of this heavy red soil was covered to an average depth of about 12 inches with drift soil of a light sandy nature. During the first week in May, 1937, the edges of this drift were topdressed with 90 lbs. of superhosphate per acre to encourage the growth of grass which was shooting. A week later a mixture of Guyra oats and Cape barley and lupins were broadcast by hand at the rate of 60 lbs. and 4 lbs. per acre respectively, and then harrowed. An application of 90 lbs. of superphosphate per acre was made by means of a "dropper" topdresser. In June, pie-melons, Dwalganup subterranean clover and Wimmera rye grass were sown on the places where the lupins and cereals were growing thinly. The area on the south side of the road, approximately 36 acres, was planted in mid-June with oats, Black barley, lupins and superphosphate at the same rates as on the northern area. Here a combined cultivator drill was used.

Soil to a depth of two feet was removed from this area in twelve months.
L. J. H. Teakle, Photo.

Despite a long dry spell which commenced early in July and lasted for six weeks, the growth of the lupins and cereals exceeded all expectations. Dr. L. J. H. Teakle, a member of the State Soil Erosion Advisory Committee, who at the writer's request inspected this area in September, 1937, reported as follows:—

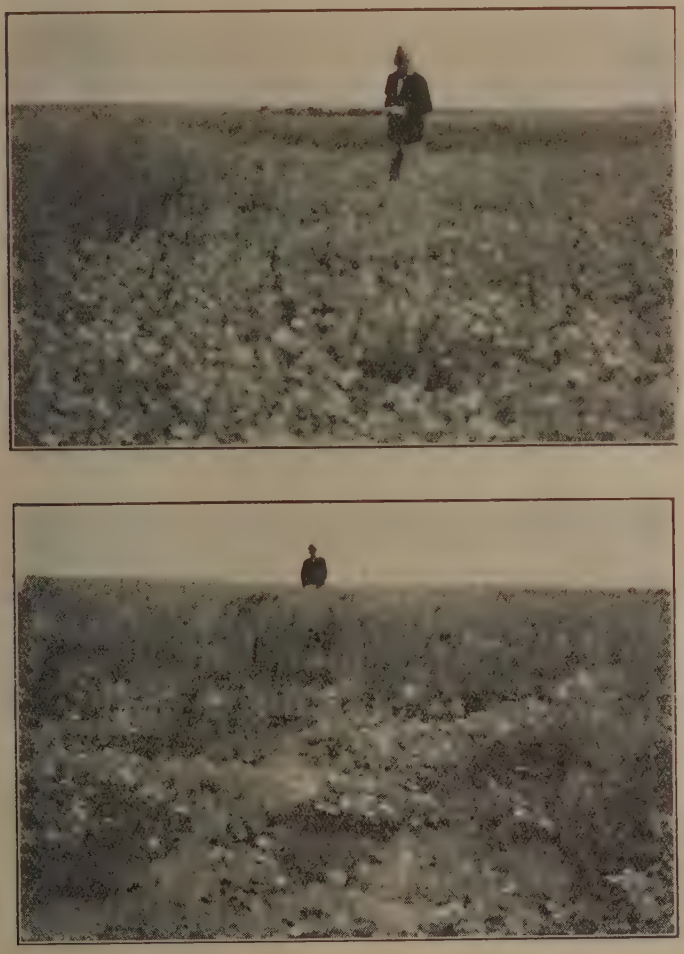
"Inspection of the area showed several conditions—

1. Blown sand—

   (a) Deep areas. Where the sand had banked up to a foot or more in depth, a good stand of lupins, barley and oats had been established as a result of sowing and the application of superphosphate.

   (b) Where a shallow surface layer of about 6 inches had been spread over strong york gum land the vegetation consisted mainly of capeweed which had made a very strong growth and was about 10 to 12 inches high.

2. Where the subsoil sand was exposed, the crop of barley and lupins had been sown but the barley had failed to make growth apparently on account of soil poverty, while the lupins were making very satisfactory growth and should provide a good seeding for next year. Fortunately this type appears to be fairly set and should not drift to any extent during the summer months.



Drift soil covering richer ground. Capeweed in foreground growing on 6in. of soil. Barley, oats, and lupins in background growing where sand deposit is deeper.

L. J. H. Teakle, Photo.

3. Limestone outcrops have been exposed in certain patches and it appears that about 2 feet of sand or more has been shifted in certain patches. Little or no growth can be established on these limestone areas.

Certain facts provided by Mr. Mitchell are of interest. In one place along this road, a netting fence which had been completely covered was uncov-

ered as a result of a heavy blow in February, 1937, and it was necessary to attach about 18 inches of netting at the bottom to make the fence rabbit proof. Subsequently, the sand was blown back over this area and now is just about the right height at the fence. Mr. Mitchell estimated that, in the course of a few months, 6 feet of sand had been shifted at the side of this fence.

DRIFT CHECKED ON NORTH SIDE OF ROAD.

Two fences have been covered here by drift sand. Lupins, barley, and oats have stopped the drift.

L. J. H. Teakle, Photo.

The affected area as a whole appears to be fairly well covered at the present time with lupins, barley and oats, and should show little or no drift in the future if judiciously stocked. Some subterranean clover has been planted and is making fair progress, and melons have been sown recently on some of the parts which are at present thinly covered by vegetation.

The crop of voluntary lupins on some of the area is very encouraging. Mr. Mitchell stated that he had known no lupins to be on the ground for at least 15 years, but, following the removal of the surface soil by the wind large numbers of seeds were uncovered and this year these have germinated and in many areas have produced excellent stands."

There are some thin areas which will need attention during the summer, and should they show signs of drifting it is Mr. Mitchell's intention to cover them with bushes, and after the first rains he will sow them with lupins and cape barley, while the whole area will be topdressed with 90 lbs. of superphosphate per acre next year. The area will not be stocked this year, and has been securely fenced off against stock (the paddock is rabbit proof) and fire breaks have been provided.

Regarding the programme of reclamation for the coming season the following methods of controlling sand drift in the 15 to 20-inch rainfall area of this State is recommended:—

(1) Exterminate the rabbits from the vicinity and make the area stock and rabbit proof.

(2) As soon as the first seeding rains have fallen sow a bushel to a bushel and a half of Cape, Atlas or bald-skinless barley and 10 lbs. of lupins per acre, using a minimum of 90 lbs. of superphosphate per acre. If lupins have not been grown on the paddock previously, it will be advisable to inoculate the seed with the bacterial culture obtainable at the Department of Agriculture at a nominal cost.

(3) Compact the sown area with a heavy roller after seeding and while the surface soil is still moist.

(4) Refrain from grazing the area until late summer and then only graze very lightly.

(5) Topdress the area annually in the autumn with a minimum of 90 lbs. of superphosphate per acre.

(6) Attempt to establish wind breaks by planting trees and shrubs which are known to do well in the locality, and by allowing the natural vegetation to make regrowth, where possible, in clumps or strips.

GENERAL VIEW OF ERODED AREA LOOKING NORTH.

A few months ago this was a barren waste. The lupins in the foreground are growing where the soil has been blown away exposing the limestone. The embankment shown in previous photo. is near the trees in the centre background.

L. J. H. Teakle, Photo.

In Western Australia, the use of lupins and barley is advocated for soils and rainfall areas where they are known to do well. Growing lupins has many advantages. They thrive on many types of light sandy soils, provide a protein-rich summer feed, which greatly increases the carrying capacity, and being a legume, improve the fertility of the soil. This is of particular advantage as the increase in the humus and nitrogen content of soil often results in a quick response of the pasture to the first early rains, an advantage worth having on reclaimed drift soils.

Mr. Henry A. Wallace, Secretary for Agriculture in the United States of America, is reported in the "Commonwealth Agriculturist," July, 1937, to have said that "the best way to stop wasteful exploitation of farm land, to lessen erosion by flood and wind, and to improve the fertility of the soil, is by careful farming

methods that continuously devote a proper share of the land to legumes and grasses and other crops, which give the ground protective cover, or when ploughed under, add to its stores of plant food."

No claim is made here regarding the originality of this method in reclaiming soil drifts. Lupins have been used for centuries in other countries for building up sandy soils and checking drift. R. L. Griffiths (S.A. Bul. 317, 1936) in an interesting publication entitled "Wind erosion of soils in the agricultural areas," mentioned that lupins are used in South Australia for the same purpose. It is hoped that the publication of this article will result in a still wider appreciation and use of the lupin in this State, and a reduction in the waste land through wind erosion.

The writer wishes to acknowledge the assistance rendered by Messrs. Benham, Mitchell and Stuart Duncan (Main Roads Board, Geraldton) for supplying much necessary information, and also to Dr. L. J. H. Teakle for the photographs, etc.

AGRICULTURAL PROBLEMS.

Agriculturists, pastoralists and primary producers generally, who may be having difficulties of any kind in connection with their production activities, are invited to communicate with the Agricultural Adviser of their district of the Department of Agriculture, when information and advice will be supplied free of charge.

Where identification of plant or stock diseases or insect pests is required, full details of symptoms should be forwarded and also samples of the diseased plant, animal tissue or insect where practicable. Plant tissue intended for examination by the Plant Pathologist should be wrapped in paper and not forwarded in airtight containers, and plant specimens for the Botanist should be pressed between newspaper and dried before despatch. With regard to animal tissue for microscopic examination, this should be forwarded in a solution of 10 per cent. formalin, or if of considerable bulk in a sealed kerosene tin containing a few ounces of formalin as a preservative. Living insects should be sent in suitable containers and dead specimens in methylated spirits.

The addresses and name of Advisers are as follows:—

Albany	H. R. Powell
Bridgetown	A. Flintoff.
Bunbury	M. Cullity.
Geraldton	N. Davenport (Government Buildings).
Gosnells	R. C. Owen.
Harvey	R. L. Cailes (Fruit); A. M. Tindale (Dairying).
Katanning	A. S. Wild
Kalamunda-Roleystone	W. H. Read, c/o. Department of Agriculture, Perth.
Metropolitan, Gingin, Chittering ...	S. E. Bennett, c/o. Department of Agriculture, Perth.
Mundaring	V. Cahill.
Narrogin	A. T. Gulvin.
Northam	F. L. Shier.
Vasse	J. M. Nelson.

GEESE.

G. D. Shaw,
Poultry Adviser, Department of Agriculture.

Geese may be raised in almost any location which has a sufficient water supply, and plenty of green feed available. The general management of geese is fairly simple, but their requirements are of such special nature that only those who have a location containing the necessary grazing can keep them profitably.

The demand is fairly restricted and therefore one must not cause the production to become too costly. The main consideration in keeping the cost low is an adequate supply of green feed. Although all poultry are naturally grass eaters, geese are especially so, and it is possible for the geese to be reared to maturity without any additional feeding. Geese can find all their requirements in the roaming of the paddocks and in the grasses they consume.

There is an objection to stocking the paddocks and pasture too heavily, as other stock will not graze over ground that has been used for the heavy stocking of geese, and therefore care must be taken to see that the land is not used to the detriment of other and more valuable stock. It is quite possible to run geese with other stock providing the geese are kept in small numbers.

Geese prefer rich succulent pasture but they will thrive on rough grasses which would be of little use to other stock.

Shedding.

It will be appreciated that birds of this size need larger space than that which is given to birds of lesser size, and they should have a house or shed all to themselves.

It is not necessary to have sheds as elaborate as those required for fowls, but one must see that the floor is dry and the shed free from draughts, although there is provision for plenty of fresh air.

The floor of the shed should be covered with some form of litter.

Geese will always return to their quarters after a day's grazing.

There is nothing more dangerous to the health of geese than damp floors for bedding purposes and every endeavour should be made to protect the stock from rheumatic cramp.

Breeding.

Geese are long living and lay to a comparatively great age. Therefore never breed from immature birds. The geese should be well grown and not under two years old. The ganders should also be well grown and not too young. The eggs of the geese during the first laying season are not satisfactory, but after their first laying they are suitable with varying degrees of fertility.

In selecting the breeding birds look for width of breast, length of body, and shortness of leg. Choose stock showing great strength of bone. Select the breeding stock early in the autumn and turn them into permanent quarters in order to allow them to settle down. If the selection or purchase of the breeders is postponed until late in the season, the best markets will be missed.

Where geese are to be mated for the purpose of market supplies, the breeders may be run in flocks giving a proportion of one male to every three or four females. Geese mate with greater success if they have access to running water.

but this is not essential to the successful breeding for table purposes. To supply the advantages of running water one can make available a large trough containing a fair depth of water.

The young geese begin to lay in July and if the eggs of the first lay are taken away and put under hens they will soon recommence to lay for a longer period.

If the geese have been encouraged to lay in permanent quarters they may be easily accustomed to lay in rough nests or in the corners of the house. As a goose covers her eggs with plenty of protective material when she is feeding, it is necessary for a liberal supply of litter to be available.

Incubation of Geese Eggs.

The period of incubation for geese is 28 to 30 days. There are three methods of incubating geese eggs: by the hen, by the geese and by artificial methods.

If hens are to be used for incubation place four or five eggs under each hen according to the size of the hen. The eggs will have to be turned daily by the attendant owing to the inability of the sitting hen to perform the operation.

The eggs should be moistened daily with warm water. It is suggested that when the eggs begin to pip they should be removed from the hen and placed in a warm box to complete the hatching; but this necessity only arises when the hen is clumsy and will tread on the necks of the young goslings.

When the eggs are to be hatched by the geese themselves cosy nests should be provided in the shed with plenty of good litter about in order to make available sufficient material for the covering of the eggs when the geese leave the nests for their feeding.

Some grain and clean water must be provided near the nest and leave the goose to do the rest.

Examine the nests for any broken eggs, which should always be removed, and any other of the eggs that are soiled should be cleaned with warm water and fresh nesting material supplied.

Do not set the first eggs laid by the geese as these are generally infertile. They are best put under a hen.

Geese are remarkably good sitters and will leave their nests once a day for food, and at each time of leaving will cover the eggs to prevent a chill.

To be successful geese eggs must have plenty of moisture and if the nest has been placed in a location which is unusually dry, it is best if the eggs are damped daily, while the goose is feeding. If the goose has had access to swimming water there is generally enough moisture on the down of the goose to give the required moisture to the eggs under her.

Artificial Incubation.

Artificial incubation is not as successful as by natural methods and therefore it is best to rely on natural means.

For artificial methods the temperature on the top of the eggs should be 102 degrees, similar to that required for ducks. Plenty of moisture is needed and this is applied by damping a piece of flannel in warm water and applying to the eggs after turning daily.

The temperature at hatching time will most likely rise to 104 degrees and this rise is generally a sign of a good hatch. It is generally advisable to incubate geese eggs in the like manner to duck eggs—plenty of moisture, well controlled heat, and long cooling with efficient turning. For the last four days, the incubator should be closed up and the hatch left to come out without any interference on the part of the operator.

Rearing of Goslings.

Goslings are the easiest of all young poultry to raise, but they should not be kept on wooden or cement floors for any length of time. They should be kept close to their nesting quarters until they are four or five days old, after which they may be permitted to graze over a limited area.

For the purpose of looking after young goslings small coops are an advantage, until such time as the gosling can be moved to a shed of larger proportions..

The sooner the young goslings are removed to their permanent quarters the better, but while they are small it is advisable to keep them in smaller yards by providing hurdles or other means of restraint.

If it is necessary to separate the goslings from their mothers, it will be essential that they be sheltered from the weather in a shed which must be provided with plenty of dry bedding, and their entire food supply must be given to them.

After the first few days they can look after themselves; but do not neglect them. They require little heat and after the first fortnight all heat can be withdrawn. Beware of cramp. This trouble is caused by damp floors, so see that the house has dry floors for camping purposes, free from draughts, but one that is properly ventilated.

Feeding of Goslings.

The feed given to goslings is similar to that given to young ducks, except that it must be remembered that geese are grass feeders and grass should therefore be given to goslings for their first meal. Mix a mash of 4 parts pollard, 4 parts bran, ¼ part meatmeal, ¼ part bonemeal with 1 part greens chaffed up very finely. Mix the mashes with plenty of skimmed milk, and give all the skimmed milk that they will drink.

At about four weeks old the cut grass can be left out of the ration as the goslings are by now grazing over fair areas. The daily ration may be reduced if the young goslings are grazing over good pasture where they are finding most of their requirements of natural foods.

For geese it is essential that they be reared on natural foods and after six weeks they should be able to find all their food by grazing except during the dry summer months or in those drier districts where the natural foods have dried up. Their range should not be restricted and although swimming is not a necessity they will do better where running water is available or where the geese have access to swampy grounds.

Goslings should be ready for the market at about five months and any that are not required for market until after that age should be treated on similar lines to the old geese and turned out into the paddocks for grazing purposes.

As the feed diminishes in the paddocks the geese should be supplied with a morning mash, before being turned out to graze each morning.

After the harvest it is a good plan to let geese have the run of the paddocks where they will be able to find a lot of food. At all times see that there is a plentiful supply of shell grit and hard grit. Both these are essential to good health.

Goslings can with advantage have onions incorporated in their rations.

Feeding of Mature Geese.

Owing to the absence of a crop geese should not be fed grains in the dry state. Boiled wheat or oats mixed with bran and pollard, and the usual quantities of meatmeal and bonemeal mixed with a fair proportion of greens, make a good meal. Do not make the mash too sloppy; a dry crumbly state is the best.

As the geese are naturally grass feeders it is necessary to feed grass at all times. Of course if the geese are grazing over paddocks which are growing plenty of grasses the greenfeed can be left out of the mash.

If the natural grasses have dried up and there is no means of providing greens in the mash, recourse must be made to steamed lucerne chaff and other similar materials.

When about to fatten geese that have been on grass and are brought in for marketing, hand feeding must be practised by giving them the mashes of pollard and bran, with only a little meatmeal. Give plenty of boiled or soaked grains.

For fattening purposes geese should be confined in small yards. They should have a plentiful supply of clean water sheltered from the direct rays of the sun. Give them the mash in the morning and at midday, and for the evening meal the ration can be varied by supplying boiled or soaked grains.

Plenty of skimmed milk before them all the time will be an advantage.

Chopped onions are an excellent tonic for both old and young and the top of onion plants can always be fed to the geese.

THE PEAT SOILS AND RELATED SOILS OF WESTERN AUSTRALIA.

II.—A SOIL SURVEY OF HERDSMAN LAKE

BY

L. J. H. Teakle * and B. L. Southern.†

SUMMARY.

A soil survey of a reclaimed marsh, known as Herdsman Lake, in the Perth metropolitan area is discussed.

Five new soil types are described and an additional type correlated with the Muchea sand previously described for Western Australia.

The soil types fall into three main groups:—

(a) Peaty sands and loams of the marginal areas.
(b) Acid to strongly acid colloidal, pulpy peats of the sedimentary type.
(c) Marly peats of the colloidal, pulpy type.

The marl appears to be the result of the decomposition of shells of a native snail (*Isidora dispar*) which must have existed in enormous numbers during the progress of the peat formation, as some of the soils contain from 40 to 55 per cent. calcium carbonate to depths greater than 7 feet.

Excessive acidity on portions of the Njookenboroo peat was found to be the cause of sterile patches. This acidity is due to the oxidation of iron sulphides, probably marcasite, and a reaction as low as pH 1.23 was encountered in the 10 to 24 inch layer at one site.

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Phosphate and potash are generally low, but high figures were obtained in some instances.

Burning of the peat should be avoided as far as possible.

Market gardening has proved generally unsuccessful on the formation but there is strong evidence of possibilities for satisfactory pasture development. The use of suitable pasture varieties, liberal and appropriate fertiliser treatment and proper management of the pastures are recommended.

INTRODUCTION.

In the first paper of this series (Teakle and Southern, 1937) a general review of the properties of peat soils was attempted, and available information concerning the extent and properties of peats and related soils of poorly-drained areas of the south-west coastal areas of Western Australia was brought together and discussed. It was pointed out that the extent of poorly-drained soils in this area would probably amount to several hundred thousand acres, but the area of true peats—those soils containing less than 40 or 50 per cent. of mineral matter—would be relatively small.

Some of these soils are highly productive for potatoes, vegetables, summer forage crops and pastures, but considerable areas are of low fertility for various reasons, and care must be taken in making selections for agricultural development. It was further mentioned that the utilisation of peat lands requires specialised technique and management. Fertilisers, frequently including minor elements such as manganese and copper, are of great importance, and stable manure is valuable for the inoculation of peat with beneficial bacteria. The watertable should be controlled to within two or three feet of the surface, particularly on account of shrinkage on drying, and irrigation is generally advisable and necessary during dry spells.

The successful development of certain of the metropolitan "swamp" lands led to the reclamation of a marsh known as Herdsman Lake, which lies within four miles of the centre of Perth. The history of this project and the results of examinations of the peat formations of the "lake" are presented below.

HISTORICAL.

Herdsman Lake is a marsh about 1,100 acres in area and, prior to drainage, carried a thick growth of bulrushes (*Cladium sp.*) and Yanget or Cattail (*Typha angustifolia*) with a sprinkling of paperbark (*Melaleuca pubescens*), flood gum (*Eucalyptus rudis*) and wattles (*Acacia sp.*). The area is fringed by a timber association of paperbark and flood gum on a sandy soil formation. The "lake" was usually under water for most of the year, but dried to a wet and puggy condition as the summer advanced. The following observations show the condition of the "lake" at various periods:—

Date.	Water Level. Feet above mean sea level.	Depth of Water. Feet.
May, 1895	dry	0
October 5, 1895	30·04	2·04
October 23, 1895	29·81	1·81
March, 1896	dry	0
September, 1919	32	4
November 10, 1920	33·99	5·99
October 2, 1922	34·80	6·80

Its main value was a habitat for wild duck, which attracted sportsmen of the metropolitan area.

The first steps toward reclamation were made in September, 1919, when Mr. Arney, of the Public Works Department, examined the formation. He found the area to be covered by about four feet of water, but was able to obtain soil samples to a depth of from three to seven feet below the surface of the peat at 21 sites. The approximate positions of these sites are shown on the map thus: ‡‡12. The samples of soil were examined by the Government Analyst (Mr. E. A. Mann) and compared with material obtained from the Roselea Nursery, Osborne Park. The results of these analyses are reported in Table 1.

TABLE 1.

Chemical properties of samples collected by Mr. Arney in September, 1919.
Results expressed as per cent. on the air dry basis.

Site.	Description when Air Dry.	Probable Soil Type.	Loss on Ignition.	$CaCO_3$.	Organic Matter and Combined Water.
			%	%	%
1	White sand ...	Joondanna peaty sand ...	...	...	3·09
2	Light brown marl	Herdsman marly peat ..	50·03	36·2	26·83
3	White marl ...	do. do. ...	51·21	44·4	25·50
4	Do. ...	do. do. ...	50·78	46·4	24·52
5	Do. ...	do. do. ...	52·13	41·1	28·00
6	Do.	do. do. ...	50·30	21·2	34·48
7	Brown peat ...	Njookenboroo loamy peat	42·73	...	29·86
8	Dark sandy ...	Joondanna peaty sand ...	9·64	...	8·28
9	White marl ...	Herdsman marly peat ...	52·34	8·00	21·43
10	Dark marl ...	do. do. ...	49·82	21·0	33·03
11	Pale brown marl ...	do. do. ...	50·10	32·4	27·16
12	Light brown marl	do. do. ...	49·94	23·1	29·33
13	Dark marl	do. do. ...	57·88	8·18	40·50
14	Do.	do. do. ..	47·67	7·77	33·83
15	Dark	Joondanna peaty loam ..	20·71	...	20·71
16	White marl ...	Herdsman marly peat ...	46·83	30·4	28·25
17	Do.	do. do. ..	50·66	38·3	27·28
18	Do.	do. do. ..	49·98	53·9	20·28
19	Do.	do. do. ..	50·22	51·7	21·51
20	Dark marl	do. do. ..	51·91	24·7	32·61
21	Very dark marl ...	do. do. ..	59·07	7·05	42·63

The soils of Osborne Park, obtained from the Roselea nursery, showed the following properties:—

Soil Description.	Organic Matter. Per cent.	Ca CO_3. Per cent.
1. Very dark swampy peat	53.63	0.30
2. Red swamp	21.37	0.59
3. Swamp and sand of borderland	11.84	0.18

It will be seen that the soils are generally marly peats, but in addition a number of samples of peat and sandy types were obtained.

Mann classified two of these samples as first class, 11 as second class and eight as third class, and expressed the opinion that only a small portion of it would compare with the best quality of market garden land as found at Osborne Park.

Arney and Mann concluded that, with certain precautions being taken, the "lake" bottom would be suitable for vegetable and fodder crops. It was judged that the best soils were on the east of the "lake" and that, in general, the Herdsman lake soils were inferior to those of Osborne Park. It was also advised that further chemical work would not be warranted until the area had been drained, as the drainage would remove soluble salts and, perhaps, alter other properties.

Drainage work commenced in March, 1921. A main drain was constructed from Osborne Park and passed through the north-western portion of the "lake" in its course to the ocean. Subsidiary drains served the area itself and the system was put into operation on May 13, 1925. By means of a lock at 26.18 feet above mean sea level, the watertable can be kept at a depth of about two feet below the present surface which averages 28.00 feet. Irrigation from the drains may be effected by means of locks, making use of the large volume of good fresh water (see Table 13) which comes in from Osborne Park.

During the course of the work a number of bores were put down with the object of determining the depth of the peat and the nature of the underlying mineral base. The results were as follows:—

Bore No.	Depth of peat.	Nature and thickness of underlying strata.
	feet.	
4	15½	Marl (1 foot), blue clay (3 feet), on limestone.
5	8½	Sand.
6	10	Sand.
7	12	Sand.
8	8½	Marl (10 feet) on limestone.
9	14	Sand.
10	18½	Sand.
11	15	Sand.
20	16	Sand.
30	11½	Sand.

The location of these bores is shown on the map.

This information shows that the main body of peat ranges from about eight to 18 feet deep and generally rests on a sandy bottom. Marl, blue clay and limestone may be encountered in some positions.

Following drainage, further samples of the soils of the "lake" bottom were obtained on 27th January and 25th March, 1926 and examined in the Government Chemical Laboratory. Some 10 sites were examined but all proved to be from the one soil type—the Herdsman marly peat. The location of these sites is shown on the map in Roman numerals thus:—IV. The results of the analyses are included with those of the present work.

In a report of July, 1926, it was concluded "the present figures show that the soil of the eastern half of the lake is similar to that of the western half, being a marl with considerable organic matter such as would form an excellent soil were it not for the excessive quantities of common salt and other soluble salts present. These are doubtless driven well down by the rain during the wet season and, it is certain, will be largely removed by further drainage, which should also improve the quality of the subsurface water for irrigation." Further exam-

ination led to the conclusion, in a report on 15th September, 1930, that the portion of the "lake" near the main drain had been sufficiently reclaimed to permit the growth of lucerne, tomatoes, melons, many vegetables and fodders.

However, results were generally disappointing and certain patches on the western side of the formation failed to support growth of any kind following reclamation. The sterility was ascribed to the burning of the peat, and the extent of the "burnt" area was mapped by Surveyor Urbahns in April, 1933. Later in the year the "burnt" soils were examined by the writers and it was discovered that excessive acidity and not burning was the most probable cause of the sterility. Damage from burning is usually of a temporary nature only and this trouble proved very persistent and associated with abnormally high degrees of acidity.

THE SOIL SURVEY.

Following this discovery, the Department of Agriculture was requested to make an examination of the soils of the "lake" and, following a preliminary inspection in December, 1933, a detailed soil survey was carried out during January and February, 1934. Traverses were made at about five chain intervals and sampling carried out to a depth of about seven feet, using a Fränkel borer. As a result of the examination of the area some six soil types were recognised and mapped and type samples taken for comprehensive laboratory investigation in the Government Chemical Laboratory.

It was found that three main groups of peat occurred on the "lake."

(1) Sedimentary or pulpy peat.

(a) acidic in reaction.

(b) marly.

This type of peat is formed by precipitation in standing water.

(2) Fibrous—pulpy peat.

(3) Peaty sand and muck.

The shore formations consist of sandhills and low sandy banks, sometimes showing accumulation of bog iron ore in the subsoil, but more generally exhibiting humus accumulation or incipient "coffee rock" in the vicinity of the watertable.

The marginal peats appear to be normally acidic in reaction but small areas have developed extreme acidity on account of the oxidation of iron sulphides, generally in the form of the mineral marcasite, to form sulphuric acid and iron sulphates. This reaction has been discussed by Segeberg (1937). By contrast, the bulk of the central portion of the formation has been transformed into a marly peat apparently as a result of invasion by fresh water snails (*Isidora dispar*) and possibly crustaceans, the shells of which have been incorporated in the peat. As a result of reaction between the shelly material and the sulphates, gypsum is a very common constituent of the peats throughout the area.

The marginal areas show a layering of the calcareous peat and the acidic gypseous peat in some portions and it is evident that there have been changes in the environment during the laying down of the peat. At least two periods of marl formation in the marginal peats appear to have occurred and would correspond to very favourable conditions for the development of the snails.

The pulpy peat, which is of the extreme colloidal type, forms a hard, brittle surface layer on drying. It also breaks into a mosaic of lumps separated by cracks frequently a foot or more in depth. Vigorous cultivation is required to reduce some of these types to a satisfactory tilth.

A number of large springs feed the formation in the north portion and associated with these are peats of a more fibrous character. They are extremely wet and sodden and difficulties in drainage would render reclamation very difficult.

The fringe of the "lake," between the sands and the peat proper, is represented by peaty sands and loams, frequently rich in sponge spicules and diatoms. These areas carry paperbark, etc., in the virgin state, are better drained, and are recognised by farmers as the most suitable soils for market gardening.

THE SOIL TYPES.

On the basis of the nature of the layers of peat observed when a hole is dug, the soils of Herdsman "lake" have been segregated into a number of types and the location of these types mapped as a result of the observations made during the course of the soil survey. Including the marginal sands, six soil types have been recognised and examined both in the field and in the laboratory with the following results. Diagrammatic representations of the profiles are shown on the map.

(1) Muchea sand, MuS.

The marginal sandy rises and banks carry jarrah, marri, *Banksia attenuata*, *Zamia Preissii*, *Dryandra floribunda*, stinkwood (*Jacksonia Sternbergiana*), etc., and in profile show the following layers: –

Ai—0 to 18-24 inches—grey humus-stained sand to light grey sand.

Aii—Below Ai—white sand.

Bi—Humus stained layer, containing a zone of cementation or soft coffee rock at about the level of the water table.

On account of its resemblance in profile to the Muchea sand described by Hosking and Greaves (1936, p. 92) this type has been named the Muchea sand. It is an advanced podsol, and consists largely of siliceous sand, falling in the coarse grade, with practically no clay or silt. The fertility is extremely low, and it is but little used for agricultural purposes on account of the need for manure and constant irrigation during dry periods.

An interesting variant included in this type was observed on the eastern shore where a low sand bank contained a layer of bog iron ore in the subsoil. This appeared to be the relic of a period when the water level was considerably higher than immediately prior to drainage, and suggests the reason for the formation of colloidal, pulpy peat in this marsh.

Chemical and physical properties of the Muchea sand are given in Tables 2 and 3.

TABLE 2.

Chemical Properties of the Muchea Sand—Results expressed as per cent., oven dry soil.

Serial No.	Depth.	Loss on Ignition.	Organic Carbon.	Total Nitrogen.	P_2O_5.*	K_2O.*	CaO.*	pH.	C : N ratio.
	ins.	%	%	%	%	%	%	%	
988	0– 1	N.D.	5·95	·297	...	...	...	6·26	20·0
989	1–24	1·6	0·90	·031	...	...	...	6·20	29·0
990	24–78	N.D.	N.D.	N.D.	...	...	...	6·60	...
1099	0–33	1·7	1·20	N.D.	·009	·014	·076	6·21	...
1100	33–54	0·4	0·20	N.D.	·003	·007	·027	6·51	...
1101	54–78	3·1	1·32	·051	·070	·010	·021	5·27	25·9

* Soluble in constant boiling point concentrated hydrochloric acid.

TABLE 3.

Mechanical Analyses of Muchea Sand, and Sieving Analyses of the Sand Fraction of the Joondanna Peaty Sand and Peaty Loam.

Soil Type	Muchea Sand.				Joondanna Peaty Sand.				Joondanna Peaty Loam.	
Serial Number	989.	1099.	1100.	1101.	999.	1000.	1029.	1030.	1005.	1097.*
Depth (inches)....	1–24.	0–33.	33–54.	54–78.	0–12.	12–24.	0–10.	10–30.	0–12.	0–9.
Mechanical Analysis—										
Coarse sand	83·1	90·4	86·2	84·8	....	....	....	....	....	....
Fine sand	13·7	6·6	12·3	6·9	....	....	....	....	....	....
Silt	1·6	1·4	1·6	1·2	....	....	....	....	....	....
Clay	1·1	·8	·7	2·5	....	....	....	....	....	....
Loss on acid treatment	·1	·1	·1	1·9	....	....	....			....
Moisture	·2	·4	·0	1·2	....	....	....	....	....	....
Sieving Analysis (I.M.M. Sieves)—per cent Sand fraction—										
Retained on 20 mesh sieve	6·0	7·3	7·3	6·3	14·2	12·4	4·7	5·1	24·4	3·5
Retained on 30 mesh sieve	21·9	24·0	17·3	20·7	28·4	25·1	16·4	13·2	34·1	9·6
Retained on 60 mesh sieve	55·5	60·4	59·4	63·0	44·1	49·0	53·9	51·2	35·6	31·1
Retained on 80 mesh sieve	6·6	4·4	8·3	4·6	5·4	6·1	10·9	13·1	1·7	8·0
Retained on 100 mesh sieve	2·4	1·1	2·2	1·2	1·6	1·7	4·4	5·3	0·8	3·8
Retained on 120 mesh sieve	2·3	1·0	1·9	1·4	1·4	1·7	3·5	5·2	0·7	3·8
Passing on 120 mesh sieve	5·3	1·8	3·6	2·8	4·9	4·0	6·2	6·9	2·7	40·2
Total	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0

* Sample rests on a layer of spicular and diatomaceous earth.

2.—*Joondanna Series.*

The Joondanna series occurs as low terrace soils between the marginal sands (Muchea sand) and the peat proper. The surface layers of organic matter accumulation rest on a sand base which is undoubtedly similar to the Muchea sand in character. This basal sand is generally whitish, but is stained a rusty brown as a mottling. Coffee rock or humus accumulation in the B1 horizon was not observed, apparently owing to the watertable frequently being at or above the surface in the past.

The surface layers show accumulation of organic matter of the humus type, and, in some cases, is rich in sponge spicules and diatomaceous material. This organic matter is quite distinct from the colloidal, pulpy types of the "lake" bottom soils, and does not belong to the sedimentary group.

In the virgin state the series carries tall paperbark, flood gum, and wattles. Certain shrubs occur, and patches of bulrushes and yanget have been observed.

On the basis of the amount of organic matter in the surface the series has been divided into two types:—

(a) *Joondanna peaty sand—Jps.*

The profile consists of the following layers:—

0-12 inches—dark grey peaty surface on a humous sand.

12-24 inches—light grey sand, somewhat mottled with ironstaining.

below 24 inches—whitish sand, becoming coarser and sharper with depth.

At the time of sampling the watertable ranged from 1½ to 5 feet deep.

The chemical properties of this type are recorded in Table 4, and the sieving analyses of the sand fraction in Table 3.

Fertility, in terms of plant food, is very low, but the moisture relations render the type suitable for market gardening if liberal manuring is resorted to. The degree of acidity seems satisfactory, as the reaction ranges from slightly acid to slightly alkaline.

(b) *Joondanna peaty loam—Jpl.*

In the wetter portions of this series there has been a greater accumulation of organic matter and a black peaty loam has formed on the sand base which occurs at 12 to 18 inches below the surface. In some patches a layer of spicular and diatomaceous material was encountered between the peaty loam surface and the sand base. Chemical and physical properties of the type reported in Tables 3 and 4.

TABLE 4.

Chemical and Physical Properties of Soils of the Joondanna Series.—Results expressed as per cent. on the Dry Soil basis.

Serial No.	Depth.	Loss on Ignition.	Organic Carbon.	Total Nitrogen.	P_2O_5.*	K_2O.*	pH.	T.W. S.S.	NaCl.	C : N. Ratio.	Water Absorption after 3 Days.†
					PEATY SAND.						
	inches.	%	%	%	%	%	%	%	%	%	%
999	0–12	4·4	1·72	·208	·008	·010	6·08	·48	·021	8·3	46·9
1000	12–24	....	....	·011	·004	·005	6·37	....	....	....	....
1001	24–72	....	....	....	....	....	5·05	....	....	....	
1029	0–10	8·4	....	....	·023	·028	7·49	....	....	....	90
1030	10–30	....	....	....	·006	·004	7·60	....	....	....	....
					PEATY LOAM.						
1005	0–12	22·7	10·9	·728	·057	·038	3·53	1·07	·130	15·0	1
1097	0–9	24·7	12·0	....	·075	·046	6·83	1·28	·377	....	209
1098	9–12	....	....	....	....	....	7·43	....	....	....	....

* Soluble in constant boiling concentrated hydrochloric acid. † By the oven-dried sample.

From the information in Table 4 it is seen that the organic matter content ranges up to 20 per cent., but the content of phosphate and potash is distinctly low, although much better than in the peaty sand type. The reactions range from strongly acid to slightly alkaline so that some areas will require liming.

Agricultural development has been practically non-existent on this type, but, with adequate drainage, should be possible if manuring is attended to and acid patches are treated with lime or marl.

3.—*Njookenboroo Series.*

These soils form the first series of true peats and lie between the marginal Joondanna series and the central marly types. They occur as an irregular strip several chains wide and range from dark grey and brownish to black colloidal, pulpy peats. These soils dry to a hard, brittle layer on the surface and pass with depth to a gelatinous layer of pinkish brown or blackish brown moist colloidal, pulpy peat. The peat appears to rest on a blackish sandy bottom.

The reaction of these soils is typically acid to very strongly acid. Where a high degree of acidity has developed, the surface layers of peat typically show encrustations of gypsum crystals and golden yellow iron oxide both on the surface and in cracks and crevices within the mass. It is these patches which have been described as "burnt" by farmers and others, but no evidence in support of this, either in the laboratory or in the field, was obtained. Another feature of these highly acid peats is the occasional occurrence of opal, which is a concretionary form of hydrated silica.

A calcareous layer, sandwiched between acidic layers of peat, is frequently observed in this series, particularly adjoining the marly types. This layer is the result of an accumulation of snail shells and may be encountered within one or two feet of the surface as an horizon of greyish and pinkish, calcareous peat of the pulpy variety. In this survey, it has not been possible to map accurately the occurrence of this layer and the type is therefore mapped with the Njookenboroo series.

On the eastern part of the formation the surface layers of a type otherwise similar are somewhat loamy in texture, apparently due to severe burning some years ago These have been differentiated as a distinct soil type and indicated on the map.

In general, however, these peats dry to a hard, brittle mass which may be broken down to a sharp textured tilth by cultivation. Examination of this property was made in the laboratory by rubbing the air dried, sieved material between the fingers. Except where distinctly ashy or loamy, the dried peat ranged from dark grey and blackish to brown in colour and the fragments were hard, angular and sharp to the feel. Light burning and the incorporation of the ash would probably improve the physical condition rather than cause injury.

Examination in the laboratory showed that on ignition to destroy the organic matter the ash remaining exhibited the following colours: light pink, pink, pinkish brown, brown, red brown, purplish red brown and dark brown. The explanation of these colour differences is quite obscure.

In the virgin state, the soils of this series carried mixed bulrushes and yanget with occasional paperbarks and wattles.

On the basis of the surface properties, two types have been recognised in this series and each of these is subdivided into two phases on the basis of the depth of the peat.

(a) *Njookenboroo peat—Np.*

The Njookenboroo peat occurs principally on the western portion of the "lake." The profile consists of a dark grey, blackish and brownish, ironstained peat from 6 to 16 inches thick, on a pinkish and dark grey brown, gelatinous peat more or less fibrous with roots. A calcareous layer may occur in the subsoil at some sites as a pinkish and light greyish marly peat. The normal soils are remarkable on account of their acidity, which ranges, in non-calcareous layers, from pH 1.23 to 4.29. They are characterised by gypsum crystals and iron oxide stainings and encrustations, are more or less low in phosphate and potash and do not generally show excess of water soluble salts. Lime requirement is high and ranges up to 4.5 per cent. $Ca(OH)_2$ or about 25 tons of slaked lime per acre foot. See Tables 7 and 8.

In the field, these peats hold up to 400 per cent. water, but after drying, generally absorb water slowly to reach about 200 per cent. water. Some samples show little affinity for water as is shown by the figures for sample 971. Sample 1027 represents the more general conditions in which apparent equilibrium at about 200 per cent. moisture is reached in one day.

Sample.	Depth.	pH.	Original.	Moisture. After moistening for—		
				1 day.	3 days.	35 days.
	ins.		%			
971	6–15	3·05	395	35·6	41·1	109·6
1027	0–16	2·74	?	201	211	...

Adjusting the reaction to pH 5 and 7 with $Ca(OH)_2$, to simulate liming, generally had little or no effect on water absorption although in the case of sample 1027 it was reduced by this treatment to 126 per cent. and 143 per cent. respectively.

The exceptional degree of acidity of certain samples of this type suggested further examination and two 10 gram samples were leached with successive 100 ml. portions of distilled water. The results of the work are given in Table 5.

TABLE 5.

The effect of leaching with distilled water on acid samples of the Njookenboroo peat. Ten grams of air dried soil were leached with successive 100 ml. portions of distilled water.

Serial No.	992			1027		
Depth (ins.)	10–24			0–16		
Original pH	1·23			2·74		
Leaching portion ...	First 100 ml.	Second 100 ml.	Third 100 ml.	First 100 ml.	Second 100 ml.	Third 100 ml.
pH of Soil	2·14	2·50	2·83	2·95	3·14	3·14
pH of Filtrate ...	0·96	1·14	1·19	2·94	3·14	3·27

It is evident that the excess acidity is due to a free, soluble acid held in the peat and which is readily removed by washing. It is undoubtedly sulphuric acid derived from sulphide oxidation. The true peat acids appear to reach equilibrium with water at a reaction slightly above pH3.

A further point of interest was the nature of the organic matter fraction of this peat and evidence in this direction was obtained by determining the degree of decomposition of the organic matter. In the first place, the material was treated according to a modification of the Grandeau method for determining humus. In the second place, loss on treatment with hydrogen peroxide, Robinson and Jones's (1925) method for determining humification, was tried. The results are detailed in Table 6, which includes, also, results from similar treatments on samples of the Koondening calcareous peat.

TABLE 6.

Degree of Decomposition of the Organic Matter of the Njookenboroo Peat and the Koondening Calcareous Peat as determined by the modified Grandeau and Hydrogen Peroxide Methods.

Serial No.	Depth.	Organic Carbon.	Organic Carbon, x 1·724.	Grandeau "Humus."	Loss on H_2O_2 treatment.	Ratios.	
						Grandeau humus to C x 1·724.	Loss on H_2O_2 treatment to C x 1·724.
			Njookenboroo Peat.				
	ins.	%	%	%	%		
970	3–6	37·9	65·3	28·8	60·9	0·44	0·93
973	3–8	31·2	53·8	18·4	61·1	0·34	1·13
974	12–20	33·7	58·1	7·8	74·1	0·14	1·28
			Koondening Calcareous Peat.				
983	12–18	12·0	20·7	2·7	24·8	0·13	1·20
985	0–4	11·8	20·3	4·9	22·3	0·24	1·10

This information shows that although the organic matter is readily decomposed by treatment with hydrogen peroxide it is not of the nature of ordinary humus. This fact is probably of considerable importance in relation to agricultural development.

Where the peat is less than two feet in depth a shallow phase has been recognised and designated on the map by the symbol Nps.

Further chemical properties are given in Table 7 and lime requirement data in Table 8.

(b) *Njookenboroo loamy peat, Nlp.*

On the eastern part of the "lake" the surface soil in this series is loamy in texture and much lower in organic carbon than the Njookenboroo peat. The subsoil is similar in field characteristics but is also lower in organic carbon and in gypsum than the peat. While more or less strongly acid (pH4 to 6) it is distinctly less acid than the Njookenboroo peat.

The typical profile is:—

i. 0 to 6-15 inches—brown ironstained loamy peat, evidently ashy.

ii. below 6-15 inches—blackish grey and brown ironstained, gelatinous peat.

iii. below ii—dark grey, dark pinkish brown, and brownish red soft, gelatinous peat, more or less fibrous with roots.

Snail shells occur but are comparatively rare.

As with the Njookenboroo peat, this type has been subdivided into two phases on the basis of depth of peat. The shallow phase, in which the sandy bottom is encountered at depths shallower than two feet, is designated Nlps.

Further chemical properties of the soils of the Njookenboroo loamy peat are reported in Table 7, and Table 8 records data concerning lime requirements.

TABLE 7.

Chemical Properties of the Njookenboroo Soils.—Results expressed on the Oven Dry Soil basis.

Serial No.	Depth.	Loss on Ignition.	Organic Carbon.	Total Nitrogen.	P_2O_5.*	K_2O.*	$CaCO_3$.	pH.	T.W. S.S.	NaCl.	$CaSO_4$, Gypsum.	C : N ratio.
					NJOOKENBOROO PEAT.							
	ins.	%	%	%	%	%	%		%	%	%	
969	0–3	71·5	39·3	....	....	....	0	2·58	....	....	....	....
970	3–6	68·3	37·9	....	....	....	0	2·78	....	....	....	....
971	6–15	74·1	38·0	....	....	....	0	3·05	....	....	....	....
1022	0–14	41·6	....	1·14	·114	·142	0	4·29	0·91	·072	0·374	....
1027	0–16	69·1	33·5	1·61	·046	·080	0	2·74	2·08	·075	0·804	20·8
1028	16–24	42·3	22·4	1·13	·011	·035	0	3·19	3·26	·185	1·34	19·8
972	0–3	63·6	30·3	....	....	....	0	2·83	....	....	....	....
973	3–8	63·5	31·2	....	....	....	0	2·91	....	....	....	....
974	12–20	72·2	33·7	....	....	....	0	3·55	....	....	....	....
975	0–3	62·7	27·4	....	....	....	0	3·62	....	....	....	....
976	3–8	66·8	35·1	....	....	....	0	3·60	....	....	....	....
991	0–10	65·2	31·9	1·58	....	....	0	3·53	11·0	·494	9·54	20·2
992	10–24	72·0	32·7	1·48	....	....	0	1·23	17·0	·86	4·35	22·2
993	24–52	22·5	16·6	....	....	....	50·5	7·21	2·78	·764	0·97	....
994	52–72	44·0	25·0	....	....	....	7·6	6·83	2·84	·847	·92	....
1002	0–14	50·2	22·9	....	....	....	3·23	6·32	11·3	·55	7·69	....
1003	14–52	34·8	23·1	....	....	....	25·9	6·95	4·26	·752	1·99	....
1004	0–6	6·2	0·84	(Ashy material)			11·1	7·24	1·39	·104	0·86	....
					NJOOKENBOROO LOAMY PEAT.							
1102	0–9	30·2	13·1	0·912	....	....	0	5·79	0·75	·095	....	14·4
1103	9–20	50·4	20·9	1·39	....	....	0	4·86	2·36	·162	....	15·0
1111	0–15	25·2	10·2	0·686	·112	·466	Tr	6·15	0·48	·058	....	14·9
1112	15–19	48·2	28·2	1·07	....	....	0	5·09	0·94	·18	....	26·3
1104	0–12	20·1	6·5	0·528	·137	·184	0	5·79	0·46	·122	....	12·3
1105	12–21	53·6	27·2	1·23	·057	·462	0	4·64	1·26	·44	....	22·1
1106	21–39	55·8	31·5	....	·037	·038	0	4·07	2·25	·315	0·445	....
1107	0–6	41·4	18·8	1·23	·278	·046	0	4·59	0·88	·162	....	15·3
1108	6–15	50·0	22·3	....	·10	·033	0	4·18	1·59	·242	0·341	....
1109	15–36	50·0	22·0	....	....	....	0	4·37	3·39	·120	0·73	....
1110	36–60	54·8	27·5	....	·052	·023	0	4·75	2·10	·193	0·646	....

* Soluble in constant boiling point concentrated hydrochloric acid.

TABLE 8.

Lime requirements of samples of Joondanna, Njookenboroo and Koondening Soils. (Determinations were made by the method of Puri and Anand (1934) and results given to pH5, 6 and 7 in terms of pure Ca $(OH)_2$ per 100 grams of air dried soil. Assuming the field weight per acre foot of peat to be 1000 tons, the amount of carbonate of lime of 100 per cent. purity required to bring the soil to a depth of one foot to pH6 is calculated.)

Serial No.	Soil Type.	Original pH.	Amount of Pure Ca $(OH)_2$ required to bring 100 pounds of Air-dried Soil to Reaction.			$CaCO_3$ per acre foot to bring to pH6 tons per acre.
			pH5 (pounds).	pH6 (pounds).	pH7 (pounds).	
999	Jps ...	6·08	...	...	·030	*Nil*
1005	Jpl ...	3·53	0·168	0·33	0·562	4·5
1022	Nps ...	4·29	0·059	0·17	0·340	2·3
1027	Nps ...	2·74	0·414	0·61	0·814	8·2
991	Np	3·53	0·237	0·42	0·607	5·7
992	Np ...	1·23	2·309	3·00	3·907	40·6
1002	Np ...	6·32	...	...	0·133	*Nil*
1102	Nlps ...	5·79	...	0·02	0·16	0·3
1111	Nlps ...	6·15	...	...	0·044	*Nil*
1104	Nlp ...	5·79	...	0·01	0·111	0·1
1107	Nlp ...	4·59	0·015	0·09	0·229	1·2
1014	Kcp ...	4·79	0·089	0·15	0·311	2·0

Of interest is the number of high figures for phosphate and potash. As about half the figures for each constituent are high and half are low it is difficult to suggest the cause for these results. It is most probably not associated with the agricultural development of the soils and must be related to some natural phenomenon.

Agriculture on the Njookenboroo series has proved generally very unsatisfactory particularly where peats of high acidities occur. In extreme cases the degree of acidity is sufficient to cause almost complete sterility. Liming and drainage would correct this but heavy applications would be required as is shown by the data in Table 8. The low degree of humification as shown by the modified Grandeau method is probably another factor in the low productivity of these peats. However, instances of satisfactory vegetable and forage crops in this series are known, and manuring, cultivation and irrigation on the better classes of soils bring forth results.

Unfortunately, most of the agricultural development has been on the more difficult Njookenboroo peat. The loamy peat of the eastern portion of the lake seems more satisfactory but has been little developed.

When all factors are considered, it must be concluded that pasture establishment should first be effected on this peat in order to mellow the soil before attempting more intensive development.

4.—*Koondening* Calcareous Peat—Kcp.*

Areas in which the surface peat, otherwise closely resembling that of the Njookenboroo type, has been modified by the invasion of snail shells, have been differentiated and mapped as the Koondening calcareous peat. The surface layers are blackish brown to blackish grey iron stained peat of the colloidal, pulpy type

* Koondening is the native name of Herdsman Lake.

modified by an amount of shelly marl (3.5 to 21.1 per cent. in the samples analysed). In the subsoil, heavy accumulation of broken shell and shell products occurs, and this portion of the profile contains from 40 to 60 per cent calcium carbonate. It appears in the field as a light grey and pink marly peat, resembling the subsoil of the Herdsman type.

On drying, the surface peat becomes somewhat hard and brittle but is usually more or less powdery on rubbing, and readily mellows down with cultivation. The subsoil dries to a light grey to buff marly peat which is usually fairly friable.

This type merges into the unmapped phase of the Njookenboroo peat in which a layer of marly peat is encountered in the subsoil. In also occurs in association with the more highly calcareous Herdsman marly peat, but, in the field, is recognised by the small amount of shell in the surface peat.

Chemical properties of soils of this series are given in table 9.

TABLE 9.

Chemical Properties of the Koondening Calcareous Peat.—Results expressed on the Oven Dry Soil basis.

Serial No.	Depth.	Loss on Ignition.	Organic Carbon.	Total Nitrogen.	P_2O_5.*	K_2O.*	$CaCO_3$.	pH.	T.W. S.S.	NaCl.	Gypsum.	C : N Ratio.
	inches.	%	%	%	%	%	%		%	%		
982	0–3	(ashy material)	4·32	....	....	....	13·5	8·02	....	..		....
983	12–18	20·5	12·0	....	....	....	60·0	7·65	....	....	.	....
984	18–24	24·4	13·6	....	....	....	62·7	7·65	....	...		....
985	0–4	22·0	12·9	....	....	....	21·1	8·14	....	..	.	....
1019	0–8	50·3	24·6	....	....	....	4·0	7·22	1·94	·216	present	.
1020	8–16	45·9	25·1	....	....	....	6·0	7·00	2·62	·55	do.	.
1021	16–27	21·3	14·4	....	....	....	47·7	7·24	1·05	·107	do.	..
1094	0–21	44·9	23·6	1·16	·041	·352	8·9	7·48	2·00	·346	do.	20·3
1095	21–27	36·0	20·5	0·995	·039	·062	28·8	7·12	3·14	·422	do.	20·6
1096	27–54	15·9	10·2	0·598	....	....	60·4	7·07	2·20	·485	do.	17·1
1113	0–4	31·8	17·2	0·776	....	....	3·5	7·00	0·93	·098	do.	22·2
1114	4–28	22·1	9·3	0·452	....	....	40·8	7·38	0·95	·153	do.	20·6

* Soluble in constant boiling point concentrated hydrochloric acid.

On ashing, it was observed that the ash colours included light grey, brown, reddish brown, purplish red brown, fawn and buff.

The results of the analyses show no abnormalities; phosphate is low and potash liable to be high, the reaction is slightly alkaline, and the content of salt is reasonably low. While little agricultural development has occurred on the Koondening calcareous peat as yet, it should be among the more suitable types for pasture production if properly manured and managed.

5.—Herdsman Marly Peat—Hmp.

The central portion of the lake, and, indeed, the bulk of the peat formation, consists of a light grey, sometimes brownish to mustard coloured, marly peat, from six inches to two or three feet deep, resting on a pink and grey gelatinous peat, more or less calcareous in nature. The peat is definitely of the colloidal, pulpy type but is modified by the presence of the calcium carbonate which originates largely from the shells of *Isidora dispar*, the native snail so common on the "lake." It holds over 400 per cent. water in the natural state and, on drying following drainage, forms a hard crust which breaks into a mosaic with cracks 12 to 18 inches deep and 6 inches or so across.

TABLE 10.

Chemical Composition of Samples of the Herdsman Marly Peat expressed by means of Distribution Table.*

Analyses reported as per cent. Oven Dry Soil.

As there is practically no systematic variation with depth, except in certain marginal sites, each sample is given equal status irrespective of position in the profile.

Constituent.	Number of Samples in each Range.										Total Samples.	Sites Sampled.
Range, per cent. ... Organic Carbon	below 11 3	11–12 5	12–13 0	13–14 6	14–15 8	15–16 5	16–17 3	17–20 3	20–23 1	Above 23 6	40	17
Range, per cent.. .... Total Nitrogen	below 0·7 0	0·7–0·8 5	0·8–0·9 7	0·9–1·0 5	1·0–1·1 6	1·1–1·2 2	1·2–1·3 2	Above 1·3 0			27	12
Range, per cent. .... P_2O_5	less than 0·01 0	·01–·02 0	·02–·03 0	·03–·04 3	·04–·05 4	·05–·06 3	·06–·07 2	·07–·08 5	·08–·09 3	·09–·10 2	22	11
K_2O	7	5	4	5	0	1	0	0	0	0	22	11
Range, per cent. .... $CaCO_3$	0–10 4	10–20 2	20–30 3	30–40 3	40–45 9	45–50 11	50–55 4	55–60 4	60–63 1	Above 63 0	40	17
Range, per cent. .... T.W.S.S.†	below 1·0 1	1·0–1·5 9	1·5–2·0 8	2·0–2·5 4	2·5–3·0 3	3·0–4·0 4	4·0–5·0 1	5·0–10·0 1	Above 10·0 1		32	14
Range, per cent. .... NaCl	below 0·1 1	·10–·25 1	·25–·50 9	·50–·75 11	·75–1·0 6	1·0–1·25 2	1·25–1·50 2	Above 1·50 0			32	14
Range, pH Values .... pH	6·4–6·6 2	6·6–6·8 2	6·8–7·0 10	7·0–7·2 12	7·2–7·4 10	7·4–7·6 3	7·6–7·8 3	7·8–8·0 1	Above 8·0 0		43	17
Range C : N. Ratio‡	13·0–13·5 1	13·5–14·0 3	14·0–14·5 3	14·5–15·0 2	15·0–15·5 0	15·5–16·0 0	16·0–16·5 2	16·5–17·0 0	17·0–17·2 1	Above 17·2 0	12	12

* From samples collected 27th January, 1926; 25th March, 1926; 15th September, 1930; 15th December, 1933; and 12th February, 1934 and analysed in the Government Chemical Laboratory.

† T.W.S.S. stands for Total Water Soluble Salts.

‡ C : N ratio of surface samples to 18 inches deep.

The dried peat is fairly hard and brittle but with rubbing breaks down fairly readily to form a somewhat granular mass which is slightly powderly when dry. By virtue of this property, with cultivation and following pasture establishment the peat mellows down fairly well to produce a satisfactory tilth and retains its capacity to absorb water quite well.

The peat generally contains from 40 to 55 per cent. calcium carbonate and shows little variation with depth until the lake bottom is approached or on the margins of the series where abnormalities occur. The base of the peat formation appears to be a blackish sand in some instances and a dark greenish spicular clay in others. The depth of the peat ranges from about 6 feet to over 20 feet.

On account of the uniformity of the composition of the layers in the profile each sample is given equal status in Table 10. Table 10 represents a summary of all available chemical information relating to the Herdsman marly peat. The bulk of the samples represent the surface 18 inches of peat but at five sites sampling was taken to deeper layers. Some 11 samples from these sites represent soils deeper than 18 inches.

From this information it is seen that phosphate is generally low to medium and potash is low to very low in these soils. Salt (sodium chloride) is somewhat high as most samples range between 0.25 and 1.0 per cent., which concentrations are probably not sufficiently high to cause damage to ordinary crops suited to such peats. Total water soluble salts are high but consist largely of gypsum and solutes other than salt.

The content of organic carbon is low for a true peat but when the amount of calcium carbonate is deducted, assuming it to be extraneous matter, the position is altered. The per cent. of organic carbon in terms of the calcium carbonate free and moisture free soil ranges from 18.8 to 37.6 with an average of 29.0 per cent. for 19 representative samples. From this point of view the organic carbon content of the peat of the Herdsman series resembles that of the Njookenboroo and other true peats of this formation.

Further data shows the apparent specific gravity of the sieved, air dry marly peat ranges from 0.834 to 0.982 with an average of 0.905. Assuming that the surface has attained its maximum density, this means that the peat, exclusive of moisture, weighs about 1,000 tons per acre foot.

When the surface soils are considered the carbon : nitrogen ratio averages 14.7 with a range of 13.5 to 17.2. There is evidence that the ratio widens with depth as is shown by the following figures:—

Serial No.	Depth.	C : N Ratio.	Serial No.	Depth.	C : N Ratio.
	ins.			ins.	
1006	0–6	14·4	1011	0–16	13·6
1007	6–27	17·1	1012	16–45	18·2
1008	27–48	18·6	1013	45–72	33·8
1009	48–60	24·8			

The wider ratios are more in keeping with the peats of the other series described above, although the Balgay peat to be described is characterised by the narrower ratios.

In the course of the survey, two phases of the Herdsman marly peat were recognised on the basis of the depth of the surface marly layer. In the normal phase the marly character was maintained for at least six feet but in marginal

TABLE 11.

Chemical and Physical Properties of the Balgay Peat.—Results expressed on the Oven Dry Soil basis.

Serial No.	Depth.	* Loss on Ignition.	Organic Carbon.	Total Nitrogen.	P_2O_5.	K_2O.	$CaCO_3$.	T.W.S.S.†	NaCl.	pH.	Water Absorption after 3 days.	C : N. Ratio.
	inches.	%	%	%	%	%	%	%	%		%	
1014	0–8	73·3	33·5	2·29	·053	·197	0	2·84	·517	4·79	54·5 ‡	14·6
1015	8–78	75·0	38·6	....	....	....	0	4·62	1·52	5·43	....	....
1016	0–8	59·3	29·8	1·93	....	....	8·3	....	....	7·64	344	15·4
1017	8–36	44·0	23·6	1·61	....	....	15·4	....	....	7·21	....	14·7
1018	36–72	....	....	....	....	....	....	....	....	6·56	....	....

* Less CO_2. † Dried at 110° C. after treating with H_2O_2. ‡ Adjustment of the pH to 6·0 and 7·0 with Ca $(OH)_2$ had little effect on the water absorption as after 3 days 57·1 % and 60·9 % respectively was absorbed.

portions of the series a shallow phase was encountered. This phase, designated Hmps, shows about one foot of marly peat on a blackish brown, gypseous peat only slightly contaminated with shells. Below this layer typical marly peat commonly occurs.

The Herdsman marly peat has proved more or less unsatisfactory for market gardening but offers possibilities for pasture production provided adequate manuring is practised. Perennial rye grass, white clover (*Trifolium repens*), Kikuyu grass and other useful pasture plants have been observed on portions of this series cleared of the bulrush and yanget.

6.—*Balgay Peat—Bp.*

The Baygay peat is extremely wet on account of springs feeding the "lake" on the north side. It appears very fibrous in contrast with the gelatinous nature of the other peats of the formation but still contains a considerable proportion of colloidal, pulpy material. This causes it to become hard and brittle as well as fibrous when dry. It is thought that the bulk of the colloidal, sedimentary peat, however, is carried away from this area owing to the influx of spring water and deposited on other portions of the "lake."

The profile consists of a dark grey to blackish brown, fibrous peat, matted on the surface and passing with depth to a dark grey to pinkish brown, soft fibrous material. This subsurface material has the consistency of thick soup and appears more or less unaltered to a depth of 6 feet, the limit of the sampling. A few snail shells may be observed in some profiles and have effected changes in the reaction values.

Chemical and physical properties of samples of the Balgay peat are reported in Table 11.

It was noted that, on ignition, the ash of these peats showed a range of colours, including dark purplish red, purplish brown, yellowish red brown and light brown.

On account of its wetness and the difficulties which would attend drainage projects, this type is probably of restricted agricultural value but it may be possible to establish some pasture growth by broadcasting seed and fertiliser. One sample analysed proved low in phosphate but rich in potash.

In the virgin condition this type carries various rushes, bulrushes, and yanget and in this respect resembles the other main soil types of the formation.

DISCUSSION.

As a fairly complete discussion has been given in describing the various soil types, it now remains only to draw attention to some of the more important points and to present the agricultural applications of the data.

In the first place, it must be emphasised that this type of peat, the colloidal, pulpy type which is probably formed by sedimentation in standing water, is difficult to reclaim for agricultural purposes. Its texture is harsh and requires much mellowing, the degree of humification as indicated by the Grandeau figure is low and water relations are more or less unsatisfactory. This type of peat is known to bind water and to render a considerable amount unavailable for plant growth. Furthermore, as absorption of water after air drying is often slow and limited in amount, plants frequently suffer from drought unless irrigation can be practised during dry periods.

The abnormally slow and limited water absorption shown by certain samples (e.g., Balgay peat sample No. A1014) is difficult to explain. Treatment with ether and alcohol to remove fats, waxes and resins had no effect but water

absorption was hastened and promoted by treatment with N 5 NaOH. This property was again destroyed by subsequent acid treatment. It seems to be related in some way to the acidity of the peat compounds but no explanation can be offered.

Extreme acidities developed, particularly in the Njookenboroo peat, are interesting and provide evidence of the activity of sulphide oxidising organisms. Reclamation of the extremely acid patches will probably be economical only where a subsoil layer of marly peat occurs and can be incorporated with the surface soil in the course of cultivation. That diffusion or movement of materials between the layers is slow as shown by the conditions at site 991 in the Njookenboroo peat where the following layers occur—

991, 0-10 inches—blackish brown ironstained peat—pH 3.53, gypsum 9.54 per cent.

992, 10-24 inches—dark grey and pink gelatinous peat—pH 1.23, gypsum 4.35 per cent.

993, 24-52 inches—grey and pale pink marly peat—pH 7.21, gypsum 0.97 per cent., calcium carbonate 50.5 per cent.

Lime applications could be recommended to correct the acidity of the normal Njookenboroo peat but several tons per acre would be required to adjust the reaction to pH 6 which may be regarded as satisfactory for most crops. The Herdsman marly peat could be used at the rate of 5 to 10 tons per acre and well worked in.

An interesting phenomenon was the magnitude of the pH values in many of the marly peats. The reaction of marly formations may be expected to range between pH 8 and 8.5 but in only one sample was pH 8 exceeded (pH 8.02) and in most cases the reaction lay between pH 6.8 and 7.4. The lowest value recorded was pH 6.32 for a peat containing 3.23 per cent. calcium carbonate. Apparently equilibrium has not been established between the somewhat acidic peat and the alkaline calcium carbonate even where the two phases must have been in contact for centuries. The quinhydrone method for the determination of pH was used in all cases.

The water soluble salts are generally high but consist largely of constituents other than chlorides. At the time of the 1926 samplings some twenty samples ranged between 0.824 and 2.63 per cent. total water soluble salts (weighed after ignition at low red heat). The proportion of salt (sodium chloride calculated from chloride) ranged from 28.1 to 50.7 per cent. with an average of 36.4 per cent. of the total water soluble salts and the proportion in the surface 9 inches was similar to that in the 9 to 18 inches layer. At the later samplings, followed some years of drainage, the position had changed to a lower proportion of salt in the water soluble fraction. In 1930, six samples, which averaged 2.03 per cent. total water soluble salts, showed an average of 15.3 per cent. salt in this fraction and the ratio was markedly lower in the surface—12.0 per cent. as compared with 18.5 per cent. in the subsoil (9 to 18 inches). At the time of the present sampling total water soluble salts were determined on 47 samples (using the H_2O_2 method for destruction of organic matter and drying at 110°C.) four of which were abnormally high in that they ranged from 11.0 to 17.0 per cent. total water soluble salts on account of gypsum accumulations. Considering the other 43 samples, the range of total water soluble salts was 0.48 to 5.47 per cent., with an average of 2.14 per cent. The salt concentrations ranged from 0.021 to 1.52 per cent. with an average of 0.414 per cent. and constituted 19.3 per cent. of the total water soluble salt fraction on the average. In the greater proportion

of sites the ratio of salt to total water soluble salts was lower in the surface layers.

On account of the high waterholding capacity of peat, this concentration of salt, although undesirable, is not particularly dangerous and the situation appears to be improving with the progress of time.

The water soluble iron content of the soils was determined in samples collected in mason jars and sealed as rapidly as possible to eliminate contact with air. As is shown in Table 12, the strongly acid subsoils contain appreciable quantities of water-soluble ferrous iron and the highest concentration of 161 ppm. would probably be deleterious to many plants.

TABLE 12.

Water-Soluble Iron Content of Peat Samples.—Results expressed on the Dry Soil basis.

Serial No.	Soil Type.	Depth.	Moisture.	pH.	Ferrous iron.	Ferric iron.
		ins.	%		ppm.	ppm.
1218	Koondening calcareous peat	0–12	218	7·19	*nil*	faint trace
1219	Njookenboroo peat	9–15	474	3·37	161	trace
1220	Njookenboroo peat	0–10	125	4·90	*nil*	faint trace
1221	Njookenboroo subsoil ...	10–15	509	3·76	18	6
1222	Herdsman marly peat ...	10–15	340	6·83	*nil*	faint trace
1239	Clayey muck, Mandogalup swamp	9–33	175	4·99	*nil*	faint trace

Of some interest is the composition of the Osborne Park drainage water, which may be used to sub-irrigate the Herdsman Lake soils, and of the ground waters on Herdsman Lake. Information available is reported in Table 13.

It is seen that the Osborne Park drainage water is quite suitable for irrigation purposes and in most cases the subsoil water would not be deleterious to the growth of ordinary plants. Water such as was obtained at site 1023 would be regarded with suspicion and would be injurious to foliage.

Agricultural Development.

Although the difficulties attendant on the agricultural development of a deep peat of this type must be recognised in planning reclamation, once reclamation is accomplished no effort should be spared to obtain maximum productivity as early as possible. In the case of Herdsman Lake some £150,000 has been spent on drainage, surveys, and other improvements and attempts to produce vegetables and forage crops have given disappointing results in most cases. There is no doubt that the principal soil types of the formation are not suitable for market gardening and local experience is the same as that obtained in the U.S.A. with related types. There is evidence, however, that pasture production can be successfully followed on these types where not unduly acid, as, on the "lake" itself, perennial rye grass, white clover, Yorkshire fog and Kikuyu grass, as well as a number of weeds such as thistles, beard grass (*Polypogon monspeliensis*), soft brome (*Bromus hordaceus*) have made encouraging growth. The pasture growth on similar soils on Richardson swamp offers support for this conclusion.

Pasture establishment should be the next step in the reclamation of the soils of Herdsman Lake as, under pasture, the soils will mellow and become enriched in humus and micro-organisms. Little is known of the most promising range of

TABLE 13.

Composition of Drainage and Subsoil Waters on Herdsman Lake.—Results as Parts per Million in the Water.

Water.	Date of Sampling.	T.W.S.S.	$CaCO_3$.	$MgCO_3$.	$MgSO_4$.	$MgCl_2$.	KCl.	NaCl.	$NaNO_3$.	Fe_2O_3, Al_2O_3.	SiO_2.	pH.	NaCl.* / T.W.S.S. Ratio.
Osborne Park Drain	....	518	138	....	49	47	8	260	....	3	13	7·1	·628
Ground Water	March 25th, 1926	1768	367	108	209	78	11	974	5	8	8	8·2	·610
Ground Water (Lab. No. 3537)	August 6th, 1931	4040	....	....	....	....	....	379	....	....	....	3·4	·094
Ground Water	July 5th, 1935	360	....	....	....	....	....	160	....	....	....	Neutral	·444

Ground Waters collected February, 1934.

	T.W.S.S.	Magnesium.	Sodium Chloride Calc. from Chloride.	Odour.	Ferrous Iron.	pH.	
Site 999 at 63 inches	419	19	131	H_2S	*nil*	6·5	·312
Between Sites 1019 and 1022 at 18 inches	499	23	120	....	*nil*	6·5	·240
Site 1023 at 27 inches	3380	159	1590	....	*nil*	7·2	·470
Site 1104 at 28 inches	691	27	491	putrid	trace	6·4	·721

* Calculated from chloride.

plants to be sown but perennial rye grass, white clover and other clovers, trefoil and Yorkshire fog should be suitable. Deep rooted types, such as lucerne, will probably suffer from the shallow water table.

Fertilisation will be of utmost importance on the Herdsman Lake soils as they are generally low in humus, phosphate and potash and the proportion of nitrogen in the peat is relatively low. If available, farmyard manure would be most desirable to inoculate the peat and promote humus formation, but, in general, artificial fertilisers will have to suffice. Superphosphate should be used liberally and supplements of potassic fertilisers should be valuable on some portions which seem to be particularly low in potash. Sulphate of ammonia or nitrate of soda should give improved yields but nitrogen supplies should be secured by the establishment of clover in the pasture mixture. From fertiliser trials with potatoes carried out by Palmer (1933) copper salts may give improved growth and, if American experience may be applied, both copper and manganese supplements should be tried with the usual superphosphate dressing. About 28 pounds per acre each of copper and manganese sulphates should be used.

The peat formations burn quite readily. Burning may give temporary benefit but is definitely dangerous and short sighted as it reduces the level of the surface soil, thus increasing drainage difficulties, and destroys valuable organic matter. Burning should be rigidly controlled if the soils are to remain a permanent agricultural asset.

There appears to be no reason why the soils of Herdsman Lake, properly managed, should not prove a valuable adjunct, at least in the production of summer pastures, to the metropolitan dairy industry. Steps have been taken to make the land available at a low price provided certain improvements in the way of fencing and pasture establishment are provided by the purchaser. Unless the farmers using the soils make every provision for the improvement of the fertility by simple fertiliser practice and properly establish and manage the pastures, success cannot be expected and it is recommended that no effort should be spared to ensure the proper working of the soils and turn them into an agricultural asset in the metropolitan area.

ACKNOWLEDGMENTS.

Grateful acknowledgment is made of the assistance rendered in this work by officers of the Department of Lands and Surveys. Surveyor S. J. Stokes assisted in the field survey and the draughtmanship was carried out in that Department. The writers are indebted to officers of the Government Chemical Laboratory for much of the chemical work reported in the tables. It is regretted that pressure of other duties has prevented further investigation of the interesting problems arising out of the information obtained in the course of the work.

LITERATURE CITED.

Hosking, J. S., and Greaves, G. A.
1936. A soil survey of an area at Gingin, Western Australia. Jour. Roy. Soc. West. Aust. 22: 71-112, 1935-36.

Robinson, G. W., and Jones, J. O.
1925. A method for determining the degree of humification of soil organic matter. Jour. Agric. Sci. 15: 26-29, 1925.

Segeberg, H.
1937. The acidity of peat soils, especially that produced from iron disulphide, and its estimation by analysis. Bodenk. u. Pflanzenern, 4: 50-64, 1937.

Teakle, L. J. H., and Southern, B. L.
1937. The peal soils and related soils of Western Australia. Jour. Agric. West. Aust. 14: 332-358, 1937.

SOIL SURVEY OF
HERDSMAN LAKE
SWAN DISTRICT
WESTERN AUSTRALIA

SCALE OF CHAINS
10 5 0 10 20

LJH Teakle & SJ Stokes . Soil surveyors
1932

LEGEND

- Herdsman marly peat — Hmp
- Shallow phase — Hmp$_s$
- Njookenboroo peat — Np
- Shallow phase — Np$_s$
- Njookenboroo loamy peat — Nlp
- Shallow phase — Nlp$_s$
- Koondening calcareous peat — Kcp
- Balgay peat — Bp
- Joondanna peaty sand — Jps
- Joondanna peaty loam — Jpl
- Muchea Sand — Mu$_s$

PROFILES

Hmp$_s$ Hmp
Light grey 3' — shelly marly peat
Pink and Light grey — 30' marly gelatinous peat
Dark pinkish brown 48' — marly gelatinous peat
54'

Np$_s$ Np
Brownish black to brown 6' — peat often gypseous
16' Pink and grey gelatinous peat
Marly peat
Blackish to greyish 72' — sand

Nlp$_s$ Nlp
Brown 8' — crumbly loamy peat
12' Greyish black ironstained peat
21' Pink and grey gelatinous peat
Blackish to greyish 72' — sand

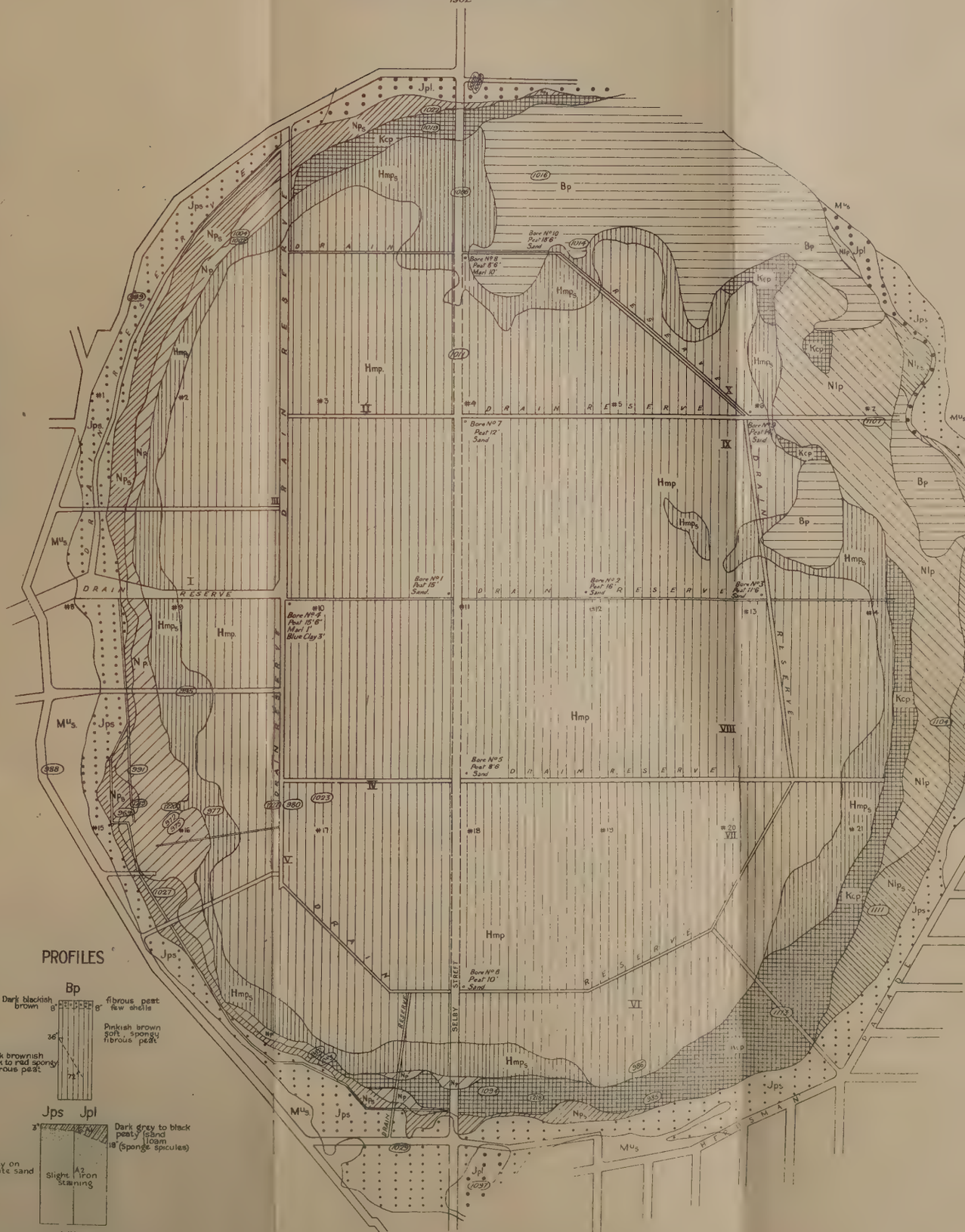
Kcp
6' Grey brown, brown to brownish black peat
12' with some shells
18' Light grey to pinkish grey gelatinous marly peat
Blackish to grey sand 72'

PROFILES

Bp
Dark blackish brown 8' — fibrous peat few shells
36' Pinkish brown soft spongy fibrous peat
Dark brownish pink to red spongy fibrous peat 72'

Jps Jpl
3' Dark grey to black peaty sand loam
18' (Sponge spicules)
Grey on white sand — Slight iron staining — A2

Mu$_s$
Brown — litter
Light gray — A1 — sand
24' 36'
White Slight brown staining — A2 — sand
Coffee brown — B1 — humus layer



CEREAL VARIETIES AVAILABLE FOR DISTRIBUTION.

R. P. Roberts, Agricultural Adviser.

In addition to the usual varieties produced at the Agricultural Research Stations as pedigree seed, limited supplies of "Ford" wheat, "Wongan" oats, and "Atlas" barley will be available this season.

The wheat and barley is available at the rate of £1 1s. per bag freight paid, or a bag of seed will be exchanged for a bag and a half of f.a.q. wheat.

The oats are available at 15s. per bag or a bag can be obtained in exchange for a bag of f.a.q. wheat.

Limits for this season have been fixed at three bags of "Ford," one of "Wongan" and five of "Atlas" barley per applicant. Seed of the wheat variety "Ford" is being produced as it has proved a good dual purpose midseason variety with the reputation of possessing a moderate degree of resistance to rust which consequently may render it of value in those districts unsuitable for "Bencubbin" on account of its susceptibility to this disease. It is a prolific yielder under good conditions, but is not the equal of "Bencubbin" in dry districts.

"Ford" was produced at the Roseworthy Agricultural College, South Australia. It has a white, tapering partly bearded ear that is inclined to shatter, and a tall medium-slender straw that stands fairly well. It is somewhat resistant to flag smut.

"Wongan" is an oat bred by D. R. Bateman, field technician at the Wongan Hills Research Station. It was produced from a cross between "Mulga" and "Burt's Early." Early growth is vigorous and slightly better than "Mulga" or "Burt's Early."

The straw is rather coarse, shorter than that of either parent, and stands fairly well. The grain is brown and both grains in the spikelet have a medium coarse awn.

The maturity is at least 10 days earlier than that of either parent and is about the same as "Palestine." The variety has been tested at several of the Research Stations in comparison with "Mulga," "Guyra," "Burt's Early" and "Palestine," and gives indications of being useful for early grazing and for grain for the drier areas, or for late planting in the wetter districts.

"Atlas" barley was introduced from California by the Department of Agriculture in 1934. It is the most important variety grown in California and is the main constituent of the barley sold under the trade name of Californian Bay Brewing Barley, some of which has been introduced to Western Australia as "Californian Six Row Barley."

Experiments at the Wongan Hills Research Station have indicated that it is quite the equal of "Cape," bald skinless or black barley as an early green feed. For grain it has yielded better than "Cape" or the local strain of "Californian Six Row," although practically indistinguishable from the latter in appearance.

When grown on light-textured soils in districts of adequate rainfall it produces a type of grain for which there is at present a ready market in England for malting purposes. It is not, however, employed for this purpose by local brewers whose technique is based on the use of two-row barleys.

At the time of writing, applications for "Wongan" and "Ford" already exceed the anticipated supply available for distribution, but there is still a small quantity of "Atlas" barley on hand. Next season it is intended to make available supplies of "Pryor" two-row malting barley.

ACREAGES OF WHEAT AND OAT VARIETIES SOWN IN WESTERN AUSTRALIA IN 1937.

Figures supplied by the Government Statistician and obtained when the acreage forecasts were collected in August, 1937.

WHEAT.

Varieties.	Acreage.	Varieties.	Acreage.
Bencubbin	1,119,370	Federation	4,996
Gluclub	390,970	Baroota Wonder Early	3,213
Merredin	309,518	Dollar	2,555
Totadgin	241,611	Major	2,499
Gluyas Early	224,520	Comeback	2,097
Nabawa	179,341	Nizam	1,996
Noongaar	173,942	Centenary	1,790
Waratah	89,591	Lotts	1,485
Ford	54,757	Turvey	1,455
Gallipoli	47,459	Sultan	1,429
Geeralying	46,835	Clubhead	1,329
Baroota Wonder	37,288	African Wonder	1,323
Dundee	27,599	Ghandi	1,151
Sword	27,321	Baringa	1,128
Bena	26,051	Drof	1,030
Gresley	23,982	Ford 3	953
Rajah	18,938	Queen Fan	918
Ranee	18,772	German Wonder	858
Canberra	17,448	Clarendon	881
Ghurka	15,379	Thew	843
Bald Early	13,605	Daphne	754
Yandilla King	12,345	Iris	739
Sutton	11,679	Golden King	687
Pusa 4	10,483	Avon	600
S.H.J.	10,027	Sailor's Fortune	570
Toby's Tusk	8,815	Warden	530
Carrabin	8,343	Caliph	529
Felix	6,876	Aussie	520
		Other Varieties	14,806
		TOTAL	3,226,529

OATS.

Varieties.	Acreage.	Varieties.	Acreage.
Guyra	245,534	Ideal	692
Mulga	185,732	Imbros	671
Algerian	178,429	Gidgee	551
Burt's Early	67,224	Glen Innes	432
Palestine	50,424	Early Ripe	316
Calcutta	4,916	Mortgage Lifter	292
Lachlan	3,711	Early Kherson	200
Ruakura	3,441	Sunrise	199
O.K.	1,436	Waikare	170
Fulghum	879	Wilga	170
Alga Kusa	755	Golden Champion	100
		Other varieties	28,291
		TOTAL	774,565

THE SHEEP AND WOOL INDUSTRY.

By Hugh McCallum,
Sheep and Wool Inspector.

Breeders of sheep in Australia are to be congratulated on the skill and enterprise they have shown in making this country's name famous throughout the wool world.

Our flocks have been developed on the most scientific and practical lines and the advance of this important industry in the State reads like a romance.

The building up and maintenance of the wool industry is essential to the progress of the State, and now is the opportune time for breeders and flock-masters to devote attention to the subject of quality in wool, mutton and lamb production.

The production of high quality wool as near to perfection as possible should be the object of every breeder, for even when low prices are ruling there is always a greater demand for superior wool. We must realise that quality wool costs no more than inferior wool to produce. The essential points to secure in a fleece are uniformity of length, evenness in quality and staple, and freedom from kemp and coarse hair. To obtain fleeces of this description is a work requiring great care in selection of both rams and ewes.

Careful periodic inspection of the flock and individual examination of each sheep should be practised by the owner. Inferior sheep must be discarded.

Every district in this vast State, more or less, has some particular advantage or disadvantage besides climate, and these peculiarities all help the production of the different types of wool displayed on the floor of the wool warehouses. A good breeder is always watchful for improved results and knows when to stop, or go on, as the case may be. We are producing, at present, a large quantity of good wool, which is a credit to the growers, but we are also growing a large quantity of wool that is uneven in fibre and this, principally, is due in many cases to a general lack of knowledge.

There are outstanding cases of many being too anxious to get to the top by "short cuts." With each advance in sheep breeding, larger frames and heavier fleeces of superior quality wool have come. The question is often asked, "Have we reached the limit of the wool carrying capacity of our sheep?" This is far from the case, and it is possible that the sheep of thirty years hence will be just as superior to the merino of to-day as the latter is to the sheep of a few years ago. The champions of to-day will be the flock of the future, especially when a better appreciation of the scientific principles of stock breeding is held by flock owners.

Many sheep breeders of to-day are allowing themselves to be too easily influenced by others and change from one blood to another too frequently. Outstanding results have been obtained by breeders who keep to the one blood over a period of years. If a breeder has not been astute enough to realise that his sheep have deteriorated and lack their former vigour there will inevitably be a general trend to degeneracy. There is no necessity for so many weaknesses, as the parent flocks are mostly of the highest grade.

There can never be any finality in sheep and wool breeding, although each generation may appear to have reached the opeimum standard. It is only necessary to look back over a few years to realise how much has been accomplished and how much yet remains to be done. There will need to be changes in the methods of sheep-breeding in the future, and many of our farmers must be educated to the necessity for observing that delay in these matters is fatal.

Obsolete methods are not of the modern age and a better type of sheep and wool must be the watchword. The breeders of high class sheep have done their part; they are still progressing. Production of quality wool must go on. In this way only can we hope to obtain the greatest source of wealth from sheep and wool.

The flocks of the world are, in the aggregate, declining, except those of Australia, and, despite the introduction of substitutes for wool, there is an unsatisfied demand for quality wool.

DAIRY PREMISES.

G. K. Baron-Hay,
Superintendent of Dairying.

Following on the decision of the Department to insist upon those premises used by farmers for the production of milk or cream conforming to the model by-laws promulgated under "The Health Act, 1911-1919," numerous inquiries have been received from dairy farmers for plans in relation to these buildings and also to the requirements of these by-laws.

In view of the above, it is thought desirable to issue this article embracing suggested plans for dairy premises which would conform with the by-laws and, at the end of the article, to give a summary of the by-laws governing dairy premises.

It is pointed out that the plans submitted are not laid down as those which must be adhered to but are intended to act as a guide to those farmers desiring to erect new premises, or who may be required by the various inspectors to alter the structure of existing buildings. Because of this, specifications are not attached to the plans, as these can be drawn out by any firm supplying the material which it is intended should be used in the construction of the buildings, and in very few instances do farmers build premises exactly according to plans and specifications, as their requirements and the lay-out of the surroundings may not be convenient.

Whatever plan is adopted ultimately, there are certain principles to which the owner must adhere, in order to conform with the regulations and to provide for the production of milk and cream under hygienic conditions.

Drainage.—The first consideration is that a suitable site should be chosen so that, during the winter months, the area surrounding the buildings should be kept as dry as possible, and an easy means available for conveying liquid matter from the milking shed and dairy.

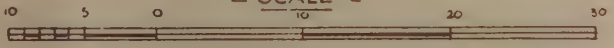
Usually milking sheds are erected with the open side facing south or east, depending upon the prevailing weather during the winter and winds during the summer months. Every endeavour should be made to provide that the stockyard in which the cows are held prior to milking should not be in front of the sheds, as, in such case, dust and sand will be blown through the shed, particularly during the summer months. This yard should be at the side of the shed, and a small yard only be immediately in front of the milking shed. This may either be concreted or treated in some other way as to be easily cleaned and kept free from dirt and dust.

Other features dealing with the construction of milking sheds and dairies are summarised below, all of which are required to ensure compliance with regulations under "The Health Act."

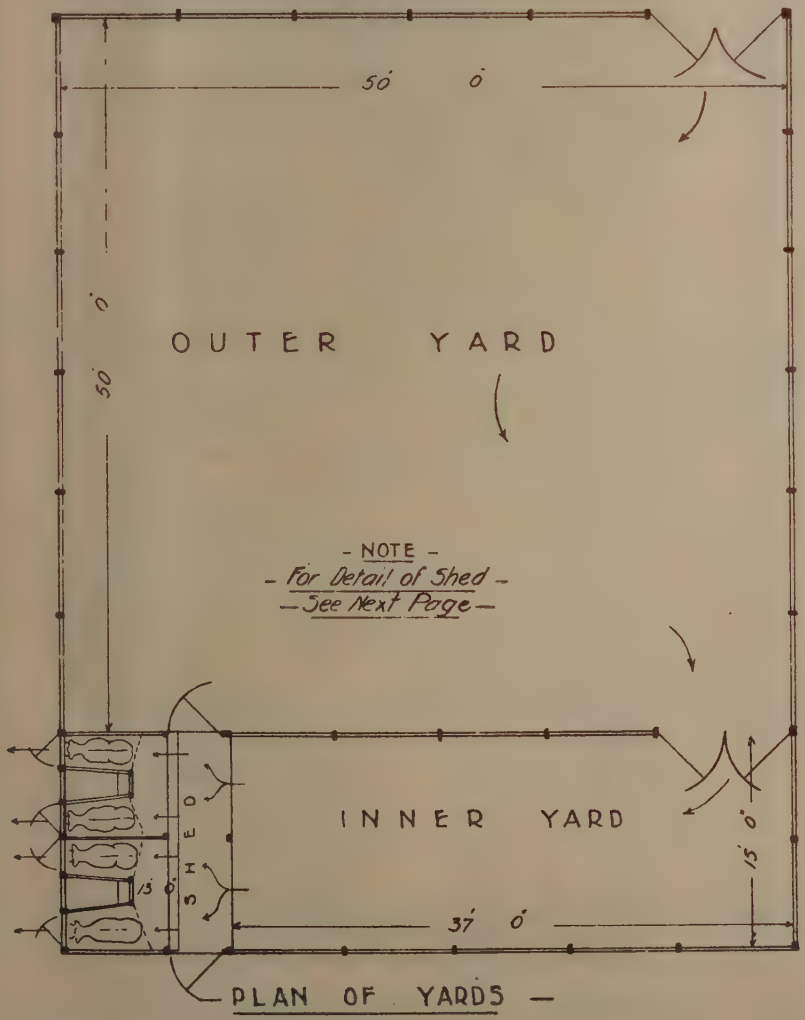
Diagram No. 1.

— BAILS & YARDS —
— FOR SMALL DAIRYMAN —
(NO FEEDING)

— SCALE —



— 10 ft. to an Inch —



— PLAN OF YARDS —

WW·7·6·21·

Diagram No. 2.

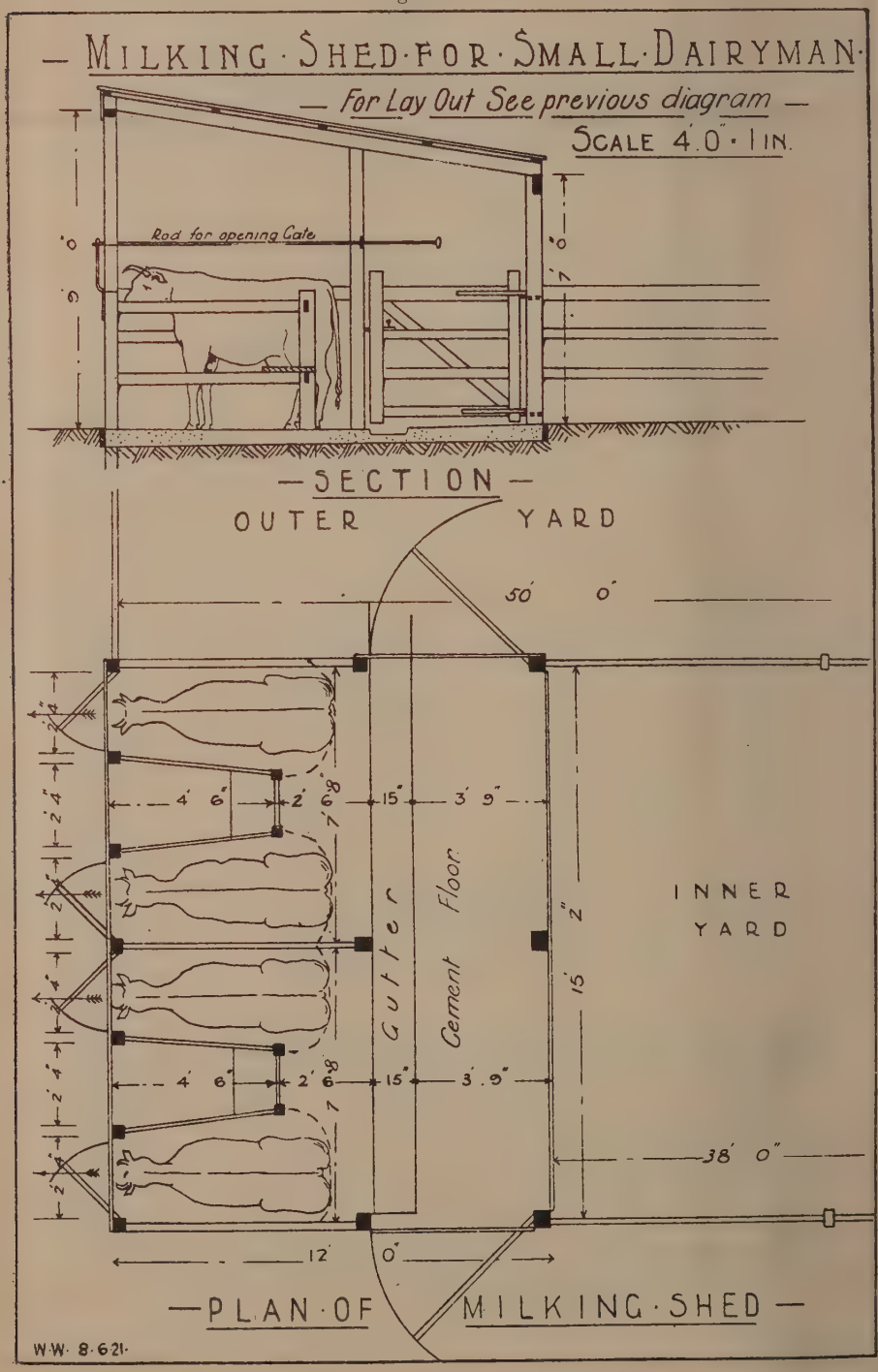

MILKING SHED FOR SMALL DAIRYMAN
For Lay Out See previous diagram
SCALE 4.0" - 1 IN.
Rod for opening Gate
9' 0"
7' 0"
SECTION
OUTER YARD
50' 0"
4' 6"
2' 6"
1' 8"
15"
3' 9"
Gutter
Cement Floor
INNER YARD
15' 2"
38' 0"
12' 0"
PLAN OF MILKING SHED
WW. 8.621.

Diagram No. 3.

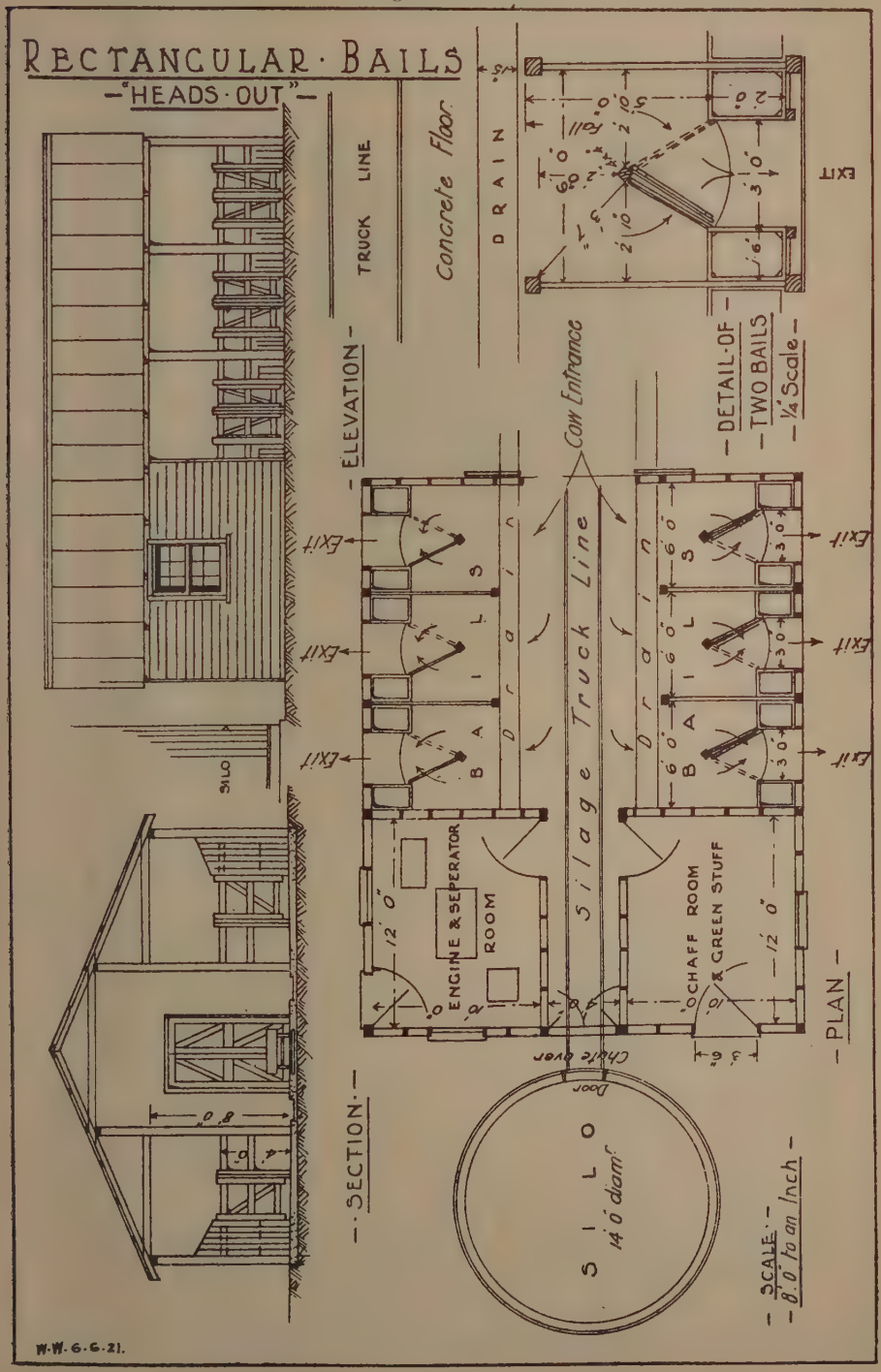

RECTANGULAR · BAILS
"HEADS · OUT"
ELEVATION
TRUCK LINE
Concrete Floor
DRAIN
DETAIL OF TWO BAILS
¼" Scale
EXIT
Cow Entrance
Silage Truck Line
Drain
BAILS
ENGINE & SEPERATOR ROOM
CHAFF ROOM & GREEN STUFF
12' 0"
PLAN
SILO
SECTION
SILO
14' 0" diam.
SCALE
8' 0" to an Inch
W.W. 6.6.21.

Diagram No. 4.

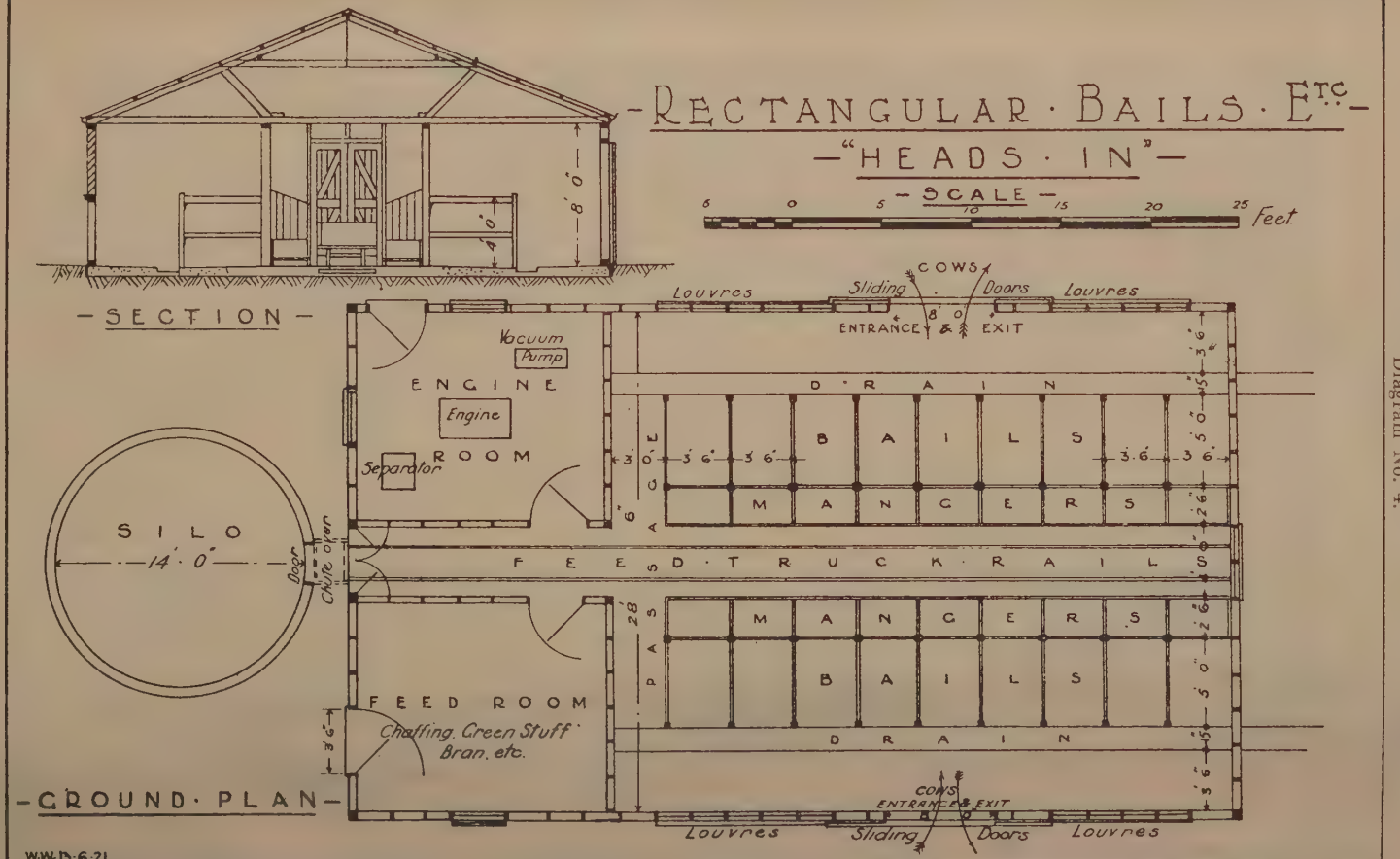

RECTANGULAR · BAILS · ETC.
"HEADS · IN"
SCALE
6 0 5 10 15 20 25 Feet
8'0"
4'0"
SECTION
COWS
Louvres
Sliding Doors
Louvres
ENTRANCE 8'0" EXIT
Vacuum Pump
ENGINE
Engine
ROOM
Separator
DRAIN
3'0" PASSAGE
3'6" 3'6" 3'6" BAILS 3'6" 3'6"
MANGERS
5'0"
2'6"
SILO
14'0"
Door
Chute 2'0"
FEED TRUCK RAILS
28' PASSAGE
MANGERS
BAILS
DRAIN
FEED ROOM
Chaffing, Green Stuff
Bran, etc.
3'6"
GROUND · PLAN
COWS
ENTRANCE & EXIT
Louvres
Sliding Doors
Louvres
W.W.D.6.21

Diagram No. 5.

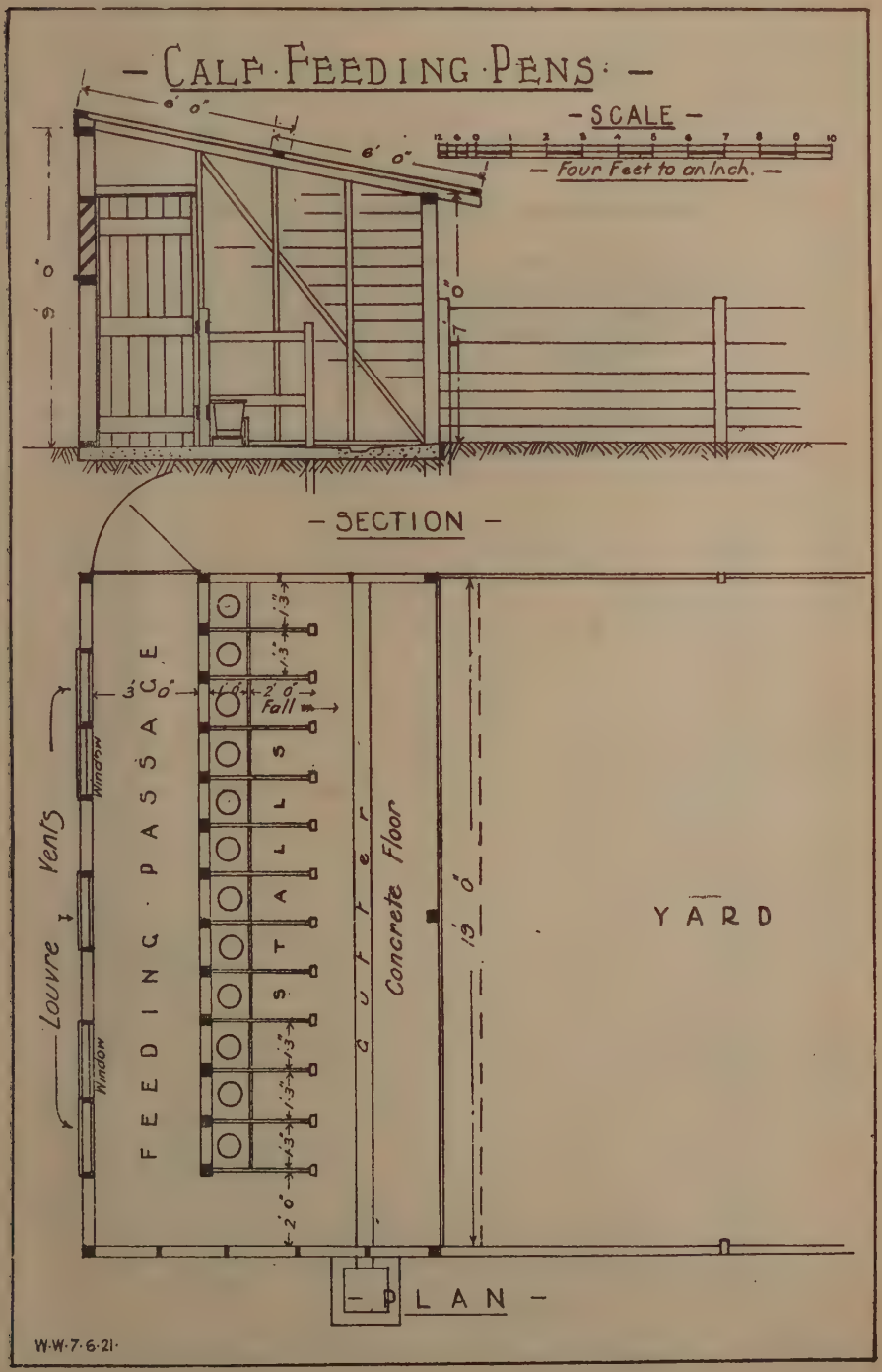
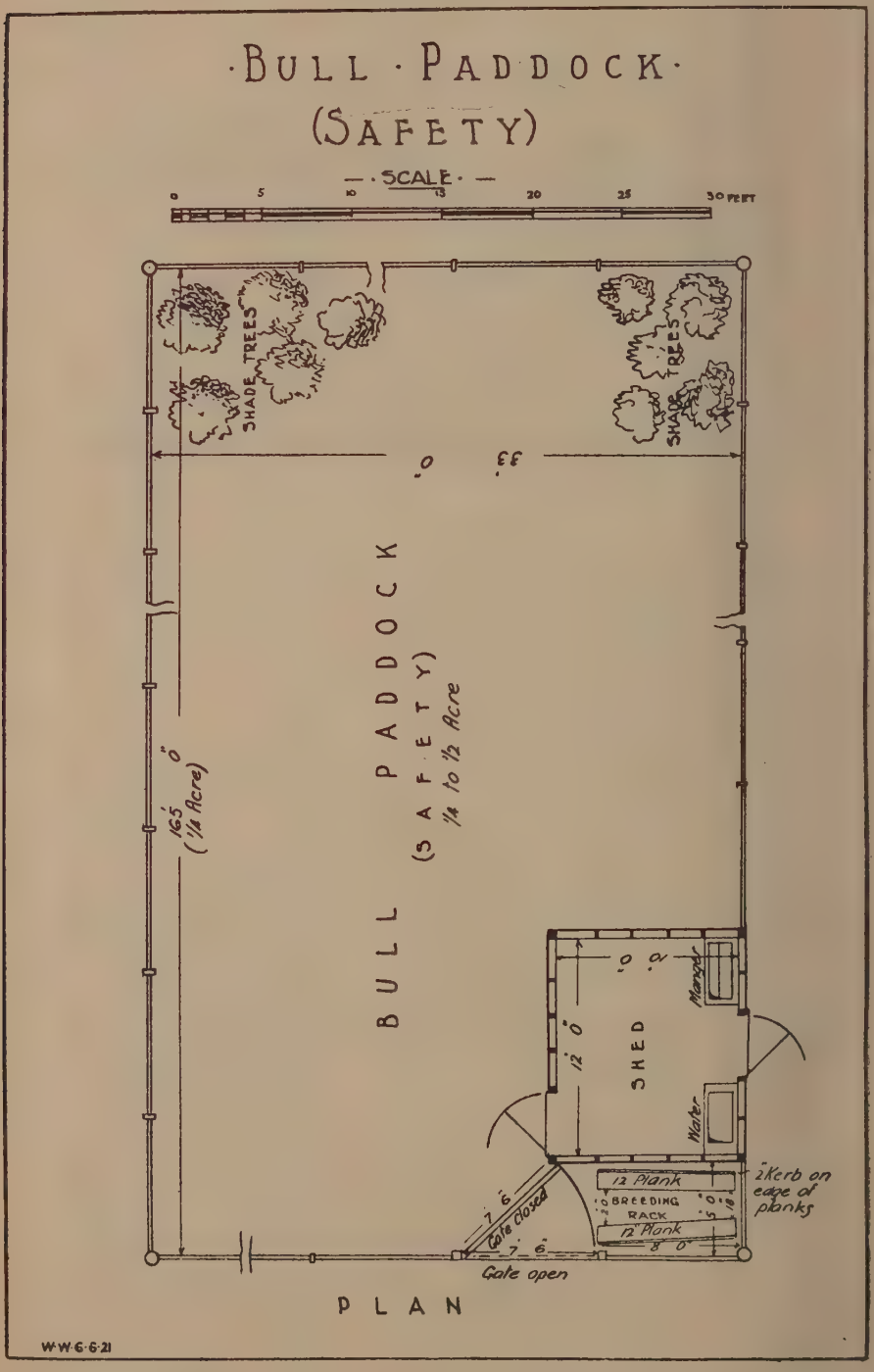

CALF FEEDING PENS
SCALE
Four Feet to an Inch.
8' 0"
6' 0"
9' 0"
SECTION
FEEDING PASSAGE
STALLS
Gutter
Concrete Floor
YARD
Louvre Vents
Window
Window
3' 0"
2' 0"
Fall
19' 0"
PLAN
W.W.7.6.21.

Diagram No. 6.


BULL PADDOCK
(SAFETY)
SCALE
0 5 10 15 20 25 30 FEET
SHADE TREES
SHADE TREES
33' 0"
BULL PADDOCK
(SAFETY)
1/4 to 1/2 Acre
165' 0"
(1/4 Acre)
SHED
12' 0"
Manger
Water
12" Plank
BREEDING RACK
12" Plank
2" Kerb on edge of planks
7' 6"
Gate closed
7' 6"
Gate open
PLAN
W·W·6·6·21

1. Every stock yard and dairy premises used by any dairyman shall be properly drained.

2. Stables used for horses shall be disconnected from the dairy premises, that is, be under a separate roof and be at least 50 feet distant from the milking shed, milking room, or dairy.

3. No animals other than dairy cattle are to be kept or allowed in the milking shed.

4. No dung, offensive liquid, or noxious matter of any kind is to be permitted to accumulate or remain upon the premises.

Premises include stock yard around milking shed, and dung should be cleaned from the milking shed and the stock yard daily. A useful method—and one which ensures that this valuable material finds its way again on to fields—is to have a sled in a convenient position away from the milking shed, which is used for placing the manure upon daily. When this sled is conveniently full, it may be drawn out on to the paddocks and the manure rapidly spread. This prevents an accumulation which may require days of work to remove, and also provides that manure is returned quickly to the land without great loss of fertilising ingredients.

5. Fowl houses or enclosures for fowls are not permitted within 50 feet of any milking shed, milk room, or dairy.

6. No live poultry are permitted in the milking shed, and an Inspector may require same to be confined within approved enclosures.

7. No piggery or enclosure for pigs is permitted within 200 feet of any milking shed, milk room, or dairy. This also means that pigs are not permitted to roam on or around dairy premises.

8. No lavatories are permitted within 50 feet of a milking shed, milk room, or dairy.

9. The regulations require that cows must be milked in an approved milking shed which has a water-proof roof, and that the lowest part of this roof shall be not less than 7 feet above the floor level.

The practice of milking cows in the open, which is still followed by several of the older established farmers in the South-West, is to be discontinued.

10. The floor of the milking shed and also the dairy must be of non-absorbent materials on a solid foundation, evenly graded, the fall being away from the feeding trough and leading into open impervious drains running the full length of the shed and wide enough so as to be cleansed readily with a broom. The lowest portion of the floor shall not be less than three inches above the adjoining ground.

11. The drains or channels are to be carried at least 20 feet from the shed or dairy, or such further distance as may be advised by the Inspector to ensure adequate disposal of the drainage matter. Where necessary, these drains shall discharge into an impervious receptacle sufficient to hold one day's flow of drainage and which shall be emptied regularly.

12. The bin for mixing fodder is not permitted in the milking room.

13. Every dairy farmer must provide a room in which to store milk or cream, complying with the following provisions:—

(a) If room is detached, it must be at least 10 feet from the milking shed. In the case of milking machines, however, the milk room may be under the same roof as the milking bails but shall be separated therefrom by an impervious wall and also separated from the engine room.

The dairy in which the cream is stored must still be detached at least 10 feet from the milking shed.

(b) It shall be at least 6 feet square and 8 feet in height from the finished floor to the lowest part of the roof or ceiling.

(c) The floor, as in the case of the milking shed, is to be constructed of impervious material which is at least 6 feet above the adjacent ground. Drainage also must be adequate as in the case of the milking shed.

(d) The room shall be ventilated and lighted sufficiently.

(e) Exterior openings are to be fitted with fly-proof screens.

(f) The walls and roof shall be constructed of approved materials unless constructed of stone, brick, or concrete.

Approved materials are asbestos preparations, iron, or wood, and an Inspector may require same to be painted where necessary.

(g) The internal wall surfaces, the ceiling, or, in those cases where a ceiling is undesirable, the underside of the roof shall be covered with hard, smooth, and impervious material, such as asbestos or smooth iron; wood is unsuitable. Such wall shall be finished so as not to afford any lodgment for dirt.

(h) Any shelves, benches, racks, etc., shall be made of smoothly dressed wood or other approved material and so arranged that they may be removed for cleansing purposes. Iron piping has proved both sanitary and convenient for the making of shelves and racks.

(i) The milk room or dairy shall not be used for any purpose other than the handling or housing of milk and the storage of milk vessels.

(j) The farmer, when required to do so, shall pave the ground immediately surrounding the milk room with a layer of not less than three inches of approved material and to a width of at least six feet.

(k) The room shall be equipped with milk strainers of approved material and design, and with an approved cooler which shall be properly connected with a cold water supply.

(l) Every dairy farmer is required to maintain his buildings, drains, fittings, machinery, utensils, tools and appliances in good repair and in a cleanly condition.

(m) Every vessel, receptacle, utensil, or other article used for manipulating milk must be thoroughly cleansed immediately after it has been used, and sterilised with steam or clean boiling water immediately before again being used. This is most important and infers that a liberal supply of boiling water will be available at the dairy for cleansing purposes. The minimum that will be accepted is a copper which is used for the provision of boiling water and is situated at the dairy.

The practice of boiling water some distance from the dairy and carrying this out to the place selected for washing dairy equipment is to be discontinued.

14. *Disease—Human.*—When a case of infectious disease affecting any member of the family or staff occurs, the same shall be reported immediately to the Local Health Authority. No affected person or one who is a contact with any infectious disease shall engage in any work on dairy premises.

15. *Disease—Stock.*—Any case of sickness or disease amongst dairy stock shall be reported immediately.

PEARS FOR EXPORT.

GEO. W. WICKENS, Superintendent of Horticulture.

One of the items that gave rise to considerable discussion at the meeting of the Apple and Pear Export Council held in Sydney during the last week in October was the question of limiting the number of varieties of pears which could be exported. It was freely admitted by practically all those present that many varieties now in cultivation are really not of sufficient quality to make them desirable for export purposes. At the same time, it was realised that some growers would experience hardship if summary action were taken. Finally it was decided that the following varieties be recommended for export:—

Beurre Hardy	Josephine	Madam Cole
Beurre D. Anjou	Packham's Triumph	Glou Morceau
Beurre Bosc	Winter Cole	Easter Beurre
Doyenne du Comice	Winter Nelis	Duchesse de Angouleme

and the undermentioned should be allowed to be exported in 1938, but after that to come up again for review—

Black Achan	Lemon Bergamot	Giblin's Seedling
Howell	Vicar of Winkfield	Beurre Britton
Marie Louise	Williams Bon Chretien	Middleton
Doyenne Bossuch	Winter Bartlett	Keiffer

All varieties other than those on the two lists mentioned above to be excluded from export.

FERTILISERS.

In accordance with the Fertilisers Act, 1928, the list of fertilisers registered for the present fertiliser year, which commenced on 1st November, 1937, is appended in tabular form.

As a guide to agriculturists in purchasing their manures, the unit values for the different forms of nitrogen, phosphoric acid and potash have been calculated from the retail prices per ton. These unit values are shown in comparison with those of the previous three years, in the following table:—

UNIT VALUES.

	1934–35.	1935–36.	1936–37.	1937–38.
	s. d.	s. d.	s. d.	s. d.
NITROGEN (N) AS—				
Dried blood, blood and bone, bonedust, and bone and flesh	22 0	22 0	21 8	23 0
Nitrate	19 7	18 3	18 2	18 1
Ammonia	12 3	11 8	11 3	11 3
PHOSPHORIC ACID (P_2O_5) AS—				
Water soluble as superphosphate	3 9	3 5	3 4	3 3
Citrate soluble as superphosphate	3 9	3 5	3 4	3 3
In bonedust	5 9	5 9	5 6	5 9
In blood and bone and other animal fertilisers ...	5 3	5 9	5 6	5 9
Basic phosphate	5 4	5 1	4 11	4 11
Acid soluble in superphosphate and rock phosphate	2 4	2 2	2 2	2 2
POTASH (K_2O) AS—				
Sulphate	6 4	6 0	6 4	6 5
Muriate	5 0	5 0	5 6	5 7

FERTILISERS.

The following fertilisers have been registered at the Department of Agriculture under "The Fertilisers Act, 1928," for the year commencing 1st November, 1937:—

Name of Fertiliser.	Reg. No.	Brand.	By Whom Registered.	Nitrogen (N) as				Phosphoric Acid (P_2O_5) as				Potash (K_2O) as		Cash Price per ton on rails at works or Perth. †
				Nitrate.	Ammonia.	Blood and Bone.	Bone-dust.	Water sol.	Citrate sol.	Acid sol.	Total.	Sulphate.	Muriate.	
A.—MINERAL.														
1. NITROGENOUS:				%	%	%	%	%	%	%	%	%	%	£ s. d.
(*a*) *Nitrogen as Nitrate*:														
Nitrate of Soda	25	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.	15·50	....	....	....	....	....	....	....	....	....	14 0 0
Do.	52	ML (in diamond)	do. do.	15·50	....	....	....	....	....	....	....	....	....	14 0 0
Do.	79	CSML	do. do.	15·50	....	....	....	....	....	....	....	....	....	14 0 0
Do.	114	Cresco	Cresco Fert. (W.A.), Ltd.	15·50	....	....	....	....	....	....	....	....	....	14 0 0
(*b*) *Nitrogen as Ammonia*:														
Sulphate of Ammonia	1	ICI	Nitrogen Fertilisers, Pty., Ltd.	....	20·60	....	....	....	....	....	....	....	....	11 10 0
Do.	24	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.	....	20·50	....	....	....	....	....	....	....	....	11 10 0
Do.	51	ML (in diamond)	do. do.	....	20·50	....	....	....	....	....	....	....	....	11 10 0
Do.	78	CSML	do. do.	....	20·50	....	....	....	....	....	....	....	....	11 10 0
Do.	115	Cresco	Cresco Fert. (W.A.), Ltd.	....	20·50	....	....	....	....	....	....	....	....	11 10 0
2. PHOSPHATIC:														
(*a*) *Rock Phosphate*:														
Pacific Islands Phosphate	23	Sickle	Cuming Smith & Mt. Lyell F.F. Pty., Ltd.	....	....	....	....	....	....	36·65	36·65	....	....	4 0 0
Do.	50	ML (in diamond)	do. do.	....	....	....	....	....	....	36·65	36·65	....	....	4 0 0
Do.	82	CSML	do. do.	....	....	....	....	....	....	36·65	36·65	....	....	4 0 0
Phosphate Powder	100	Cresco	Cresco Fert. (W.A.), Ltd.	....	....	....	....	....	....	....	34·80	....	....	4 0 0
(*b*) *Superphosphates*:														
Florida Superphosphate, 22 per cent.	2	Sickle	Cuming Smith & Mt. Lyell F.F. Pty., Ltd.	....	....	....	....	20·50	0·50	1·00	22·00	....	....	3 12 6
Florida Superphosphate, 23 per cent.	3	do.	do. do.	....	....	....	....	21·25	0·50	1·25	23·00	....	....	3 12 6
22 per cent Superphosphate	29	ML (in diamond)	do. do.	....	....	....	....	20·50	0·50	1·00	22·00	....	....	3 12 6
High Grade Super., 23 per cent.	30	do. do.	do. do.	....	....	....	....	21·25	0·50	1·25	23·00	....	....	3 12 6
22 per cent Superphosphate	56	CSML	do. do.	....	....	....	....	20·50	0·50	1·00	22·00	....	....	3 12 6
High Grade Super., 23 per cent.	57	do.	do. do.	....	....	....	....	21·25	0·50	1·25	23·00	....	....	3 12 6
"23" Super.	98	Cresco	Cresco Fert. (W.A.), Ltd.	....	....	....	....	21·25	0·50	1·25	23·00	....	....	3 12 6

(c) *Rock Phosphate and Superphosphate*:																
Phosphate Mixture 50/50	22	Sickle	Cuming Smith & Mt. Lyell F.F. Pty., Ltd.	....	....	....	..	10·00	0·50	18·50	29·00			4	1	6
Do.	49	ML (in diamond)	do. do.	....	....	....	....	10·00	0·50	18·50	29·00		....	4	1	6
Do.	77	CSML	do. do.	....	....	....	....	10·00	0·50	18·50	29·00		....	4	1	6
50/50 Phosphate	99	Cresco	Cresco Fert. (W.A.), Ltd.	....	....	....	....	10·00	0·50	18·50	29·00		.	4	1	6
(d) *Basic Phosphate*:																
Basic Phosphate	21	Sickle	Cuming Smith & Mt. Lyell F.F. Pty., Ltd.	....	....	. .	....	....	....	17·0	17·0	....	....	4	4	0
Do.	48	ML (in diamond)	do. do.	....	....	....	....	....	....	17·0	17·0	....	....	4	4	0
Do.	68	CSML	do. do.	....	....	....	....	....	....	17·0	17·0	....	....	4	4	0
3. POTASSIC:																
(a) *Potash as Sulphate*:																
Sulphate of Potash	26	Sickle	do. do.	....	....	....	....	....	....	....	....	48·60	....	15	10	0
Do.	53	ML (in diamond)	do. do.	....	....	....	....	....	..	..	..	48·60	..	15	10	0
Do.	80	CSML	do. do.	....	....	....	....	....	....	....	.	48·60	..	15	10	0
Do.	96	Sun	Westralian Farmers, Ltd.	....	....	....	....	....	....	..	..	48·60	..	15	10	0
Do.	117	Cresco	Cresco Fert. (W.A.), Ltd.	....	....	....	....	....	....	....	....	48·50	....	15	10	0
(b) *Potash as Muriate*:																
Muriate of Potash	27	Sickle	Cuming Smith & Mt. Lyell F.F. Pty., Ltd.	....	....	....	....	....	..	..	....	....	50·0	14	0	0
Do.	54	ML (in diamond)	do. do.	....	....	....	....	....	..	....	..	..	50·0	14	0	0
Do.	81	CSML	do. do.	....	....	....	....	....	..	....	..	..	50·0	14	0	0
Do.	97	Sun	Westralian Farmers, Ltd.	....	....	....	....	.	....	....	....	..	50·0	14	0	0
Do.	116	Cresco	Cresco Fert. (W.A.), Ltd.	....	....	....	....	.	....	....	.	.	50·0	14	0	0
Kainit	93	Sun	Westralian Farmers, Ltd.	....	....	....	....	..	..	..	..	..	50·0	14	10	0
Potash Manure Salts	95	do.	do. do.	....	....	....	....	....	....	....	....	....	14·0		*	
								..	..	..	....	....	30·0		*	
4. NITROGEN AND PHOSPHORIC ACID:																
Super and Ammonia, No. 1	14	Sickle	Cuming Smith & Mt. Lyell F.F. Pty., Ltd.	....	2·94	....	....	17·57	0·43	0·85	18·85	....		5	10	6
Do. .... No. 2	15	do.	do. do.	....	5·15	..	.	15 37	0·37	0·76	16·50			6	8	0
Do. .... No. 3	16	do.	do. do.	....	6·00	..	..	14·25	0·40	1·10	15·75		.	6	13	0
Do. .... No. 4	17	do.	do. do.	....	6·87	..	.	13·66	0·34	0·66	14·66		.	7	1	0
Do. .... No. 5	18	do.	do. do.	....	10·30	....	.	10·25	0·25	0·50	11·0		.	8	9	0
Do. .... No. 1	40	ML (in diamond)	do. do.	....	2·94	....	.	17·57	0·43	0·85	18·85	.		5	10	6
Do. .... No. 2	42	do. do.	do. do.	....	5·15	....	.	15·37	0·37	0·76	16·50		.	6	8	0
Do. .... No. 3	43	do. do.	do. do.	....	6·00	....	....	14·25	0·40	1·10	15·75			6	13	0
Do. .... No. 4	44	do. do.	do. do.	....	6·87	....		13·66	0·34	0·66	14·66			7	1	0
Do. .... No. 5	45	do. do.	do. do.	....	10·30	....	..	10·25	0·25	0·50	11·0			8	9	0
Do. .... No. 1	72	CSML	do. do.	....	2·94	....	....	17·57	0·43	0·85	18·85		.	5	10	6
Do. .... No. 2	73	do.	do. do.	....	5·15	....	....	15·37	0·37	0·76	16·50		.	6	8	0
No. .... No. 3	74	do.	do. do.	....	6·00	....	....	14·25	0·40	1·10	15·75		.	6	13	0
Do. .... No. 4	75	do.	do. do.	....	6·87	....	....	13·66	0·34	0·66	14·66			7	1	0
Do. .... No. 5	76	do.	do. do.	....	10·30	....	....	10·25	0·25	0·50	11·00			8	9	0
Do. .... 1 : 1	104	Cresco	Cresco Fert. (W.A.), Ltd.	.	10·00	.	.	10·25	0·25	0·50	11·00		.	8	10	0
Do. .. 2 : 1	101	do.	do. do.	.	6·87	....	.	13·66	0·34	0·66	14·66		.	7	1	0
Do. .... 3 : 1	102	do.	do. do.	.	5·15	.	.	15·37	0·37	0·76	16·50			6	8	0
Do. .. 6 : 1	103	do.	do. do.	....	2·94	....	....	17·57	0·43	0·85	18·85	....	....	5	10	6
Phosphate of Ammonia	137	Floraphos	J. A. Newman & Co.	....	15·60	....	....	31·20	....	....	31·20	....	....	35	0	0

* Price on application. † On rails Perth

FERTILISERS—*continued.*

Name of Fertiliser.	Reg. No.	Brand.	By Whom Registered.	Nitrogen (N) as				Phosphoric Acid (P_2O_5) as				Potash (K_2O)		Cash Price per ton on rails at works or Perth. †
				Nitrate.	Ammonia.	Blood and Bone.	Bone-dust.	Water sol.	Citrate sol.	Acid sol.	Total.	Sulphate.	Muriate.	
				%	%	%	%	%	%	%	%	%	%	£ s. d.
5. NITROGEN, PHOSPHORIC ACID AND POTASH:														
Potato Manure B	4	Sickle	Cuming Smith & Mt. Lyell F.F. Pty., Ltd.	....	3·75	....	....	14·50	0·35	0·75	15·60	4·50	....	7 1 0
Do. C	5	do.	do. do.	....	3·50	....	....	16·75	0·40	1·10	18·25	....	....	5 15 6
Do. E	6	do.	do. do.	....	3·50	....	....	14·00	0·30	0·70	15·00	8·00	....	7 18 0
Do. F	7	do.	do. do.	....	6·00	....	....	14·25	0·40	1·10	15·75	....	....	6 13 0
Do. G	8	do.	do. do.	....	3·50	....	....	10·50	0·20	0·60	11·30	16·00	....	9 18 6
Do. H	9	do.	do. do.	....	4·00	....	....	12·70	0·30	0·70	13·70	9·00	....	8 7 0
Do. No. 5	10	do.	do. do.	....	7·50	....	....	7·00	0·20	0·40	7·60	13·25	....	10 16 0
Orchard Manure	11	do.	do. do.	....	2·00	....	....	15·75	0·40	1·10	17·25	....	5·00	6 6 0
Special Mixture K	12	do.	do. do.	....	8·34	....	....	8·40	0·20	0·40	9·00	....	10·04	9 17 6
Do. KP	13	do.	do. do.	....	6·34	....	....	10·50	0·20	0·80	11·50	10·04	....	9 10 0
Tobacco Fertiliser	20	do.	do. do.	3·30		....	....	14·00	0·50	1·00	15·50	5·70	....	7 10 0
Potato Manure No. 2	31	ML (in diamond)	do. do.	....	3·50	....	....	16·75	0·40	1·10	18·25	....	....	5 15 6
Do. No. 3	32	do. do.	do. do.	....	3·75	....	....	14·50	0·35	0·75	15·60	4·50	....	7 1 0
Do. No. 4	33	do. do.	do. do.	....	3·50	....	....	14·00	0·30	0·70	15·00	8·00	....	7 18 0
Do. No. 5	34	do. do.	do. do.	....	7·50	....	....	7·00	0·20	0·40	7·60	13·25	....	10 16 0
Do. No. 6	35	do. do.	do. do.	....	6·00	....	....	14·25	0·40	1·10	15·75	....	....	6 13 0
Do. No. 7	36	do. do.	do. do.	....	3·50	....	....	10·50	0·20	0·60	11·30	16·00	....	9 18 6
Do. No. 8	37	do. do.	do. do.	....	4·00	....	....	12·70	0·30	0·70	13·70	9·00	....	8 7 0
Orchard Manure	38	do. do.	do. do.	....	2·00	....	....	15·75	0·40	1·10	17·25	....	5·00	6 6 0
Special Mixture K	39	do. do.	do. do.	....	8·34	....	....	8·40	0·20	0·40	9·00	....	10·04	9 17 6
Do. KP	41	do. do.	do. do.	....	6·34	....	....	10·50	0·20	0·80	11·50	10·04	....	9 10 0
Tobacco Fertiliser	47	do. do.	do. do.	3·30		....	....	14·00	0·50	1·10	15·50	5·70	....	7 10 0
Potato Manure B	58	CSML	do. do.	....	3·75	....	....	14·50	0·35	0·75	15·60	4·50	....	7 1 0
Do. C	59	do.	do. do.	....	3·50	....	....	16·75	0·40	1·10	18·25	....	....	5 15 6
Do. E	60	do.	do. do.	....	3·50	....	....	14·00	0·30	0·70	15·00	8·00	....	7 18 0
Do. F	61	do.	do. do.	....	6·00	....	....	14·25	0·40	1·10	15·75	....	....	6 13 0
Do. G	62	do.	do. do.	....	3·50	....	....	10·50	0·20	0·60	11·30	16·00	....	9 18 0
Do. H	63	do.	do. do.	....	4·00	....	....	12·70	0·30	0·70	13·70	9·00	....	8 7 0
Do. No. 5	64	do.	do. do.	....	7·50	....	....	7·00	0·20	0·40	7·60	13·25	....	10 16 6
Tobacco Fertiliser	66	do.	do. do.	3·30		....	....	14·00	0·50	1·00	15·50	5·70	....	7 10 0
Do. .... No. 2	67	do.	do. do.	3·70		....	....	13·20	0·30	0·70	14·20	7·00	....	7 14 0
Orchard Manure	69	do.	do. do.	....	2·00	....	....	15·75	0·40	1·10	17·25	....	5·00	6 6 0
Special Mixture K	70	do.	do. do.	....	8·34	....	....	8·40	0·20	0·40	9·00	....	10·04	9 17 6
Do. KP	71	do.	do. do.	....	6·34	....	....	10·50	0·20	0·80	11·50	10·04	....	9 10 0
Potato Special	107	Cresco	Cresco Fert. (W.A.), Ltd.	....	4·00	....	....	12·70	0·30	0·70	13·70	9·00	....	8 7 0
Special Orchard Manure	108	do.	do. do.	....	8·34	....	....	8·40	0·20	0·40	9·00	....	10·04	9 17 6
Orchard Manure	109	do.	do. do.	....	1·50	....	....	7·10	1·40	13·50	22·00	7·50	....	6 15 0
Vine Manure	110	do.	do. do.	....	1·50	....	....	7·10	1·40	13·50	22·00	7·50	....	6 15 0
Mixed Manure	111	do.	do. do.	....	1·50	....	....	7·10	1·40	13·50	22·00	7·50	....	6 15 0
Potato Manure	112	do.	do. do.	....	1·50	....	....	7·10	1·40	13·50	22·00	7·50	....	6 15 0
Special Mixture No. 67....	113	do.	do. do.	....	4·00	....	....	15·00	....	1·00	16·00	2·40	....	6 12 6
Potato Manure C	124	Star	Binney & Son	....	3·30	....	....	15·00	1·50	....	16·50	4·25	....	7 5 0
Do. B	125	do.	do. do.	....	3·50	....	....	13·50	1·50	....	15·00	8·00	....	7 18 0
Orchard High Grade	127	do.	do. do.	....	8·30	....	....	8·40	0·60	....	9·00	10·00	....	9 17 6

6.—MISCELLANEOUS:															
Super and Manganese†	105	do.	do.	do.	....	....	....	....	17·00	0·50	1·00	18·50	....	....	7 10 0
B—ORGANIC.															
(a) *Blood and Bone*:															
Blood and Bone	28	Sickle	Cuming Smith & Mt. Lyell F.F. Pty., Ltd.	....	....	5·00	....	....	....	15·00	15·00	....	....	10 0 0
Do.	55	ML (in diamond)	do. do.	....	....	5·00	....	....	....	15·00	15·00	....	....	10 0 0
Do.	84	CSML	do. do.	....	....	5·00	....	....	....	15·00	15·00	....	....	10 10 0
Do.	85	"G"	do. do.	....	....	6·00	....	....	....	12·00	12·00	....	....	10 10 0
Do.	89	A.N.A Surprise	C. A. Kirkby and Sons	....	....	5·00	....	....	4·00	10·00	14·00	....	....	10 10 0
Do.	92	Imperial	W. Angliss & Co.	....	....	4·50	....	....	5·00	11·00	16·00	....	....	‡9 5 0
Do.	94	Sun	Westralian Farmers, Ltd.	....	....	5·25	....	....	....	....	14·00	....	....	8 15 0
Do.	119	Cresco	Cresco Fert. (W.A.), Ltd.	....	....	5·00	....	....	....	....	14·00	....	....	10 10 0
Do.	120	A1 in circle	Haynes & Clements	....	....	5·25	....	....	3·00	9·00	12·00	....	....	‡11 5 0
Do.	121	Eclipse	West Australian Meat Export, Co., Ltd.	....	....	6·00	....	....	....	12·00	12·00	....	....	9 5 0
Do.	123	Wyndham	Wyndham Freezing, Canning and Meat Export Works	....	....	6·00	....	....	12·00		12·00	....	....	‡9 10 0
Do.	129	Star	Binney & Son	....	....	5·25	....	....	....	14·00	14·00	....	....	9 12 6
(b) *Bones*:															
Bonedust	83	CSML	Cuming Smith & Mt. Lyell F.F. Pty., Ltd.	....	....	....	3·50	....	....	22·00	22·00	....	....	11 0 0
Do.	90	W (in diamond)	Henry Wills & Co.	....	....		2·75	....	6·00	13·00	19·00	....	....	9 0 0
Do.	122	Eclipse	West Australian Meat Export Co., Ltd.	....	....		3·50	....	....	22·00	22·00	....	....	7 10 0
Pure Bonedust	118	Cresco	Cresco Fert. (W.A.), Ltd.	....	....	....	3·50	....	....	22·00	22·00	....	....	11 0 0
Bonedust	131	Star	Binney & Son	....	....	....	3·50	....	....	22·00	22·00	....	....	8 15 0
(c) *Blood*:															
Dried Blood	91	Imperial	W. Angliss & Co. (Aust.) Pty., Ltd.	....	....	12·00 as dried Blood	....	....	....	....	....	....	....	‡15 10 0
C.- MINERAL AND ORGANIC.															
Bone and Super.	19	Sickle	Cuming Smith & Mt. Lyell F.F. Pty., Ltd.	....	....	....	2·00	13·00	0·80	4·70	18·50	....	....	6 12 6
Do.	46	ML (in diamond)	do. do.				2·00	13·00	0·80	4·70	18·50			6 12 6
Do.	65	CSML	do. do.	....	9·38	....		15·00	0·50	1·55	17·05	....	....	20 0 0
Fertos	86	Floreat	T. S. Gill	....	....	....	3·75	12·00	0·30	3·20	15·50			‡14 10 0
Domestic Garden	87	Wondergrowth	W. J. Matthews	....			2·02				3·76		2 51	‡18 0 0
Manurial Insecticide	88	Kill-A-Mite	Kill-A-Mite Co.	....			1·00				14·00	1 00		4 17 6
Bone, Super. and Potash	106	Cresco	Cresco Fert. (W.A.), Ltd.	....	....		6·75	4·00		8·00	12·00		5 00	9 17 6
Special Orchard Fertiliser	126	Star	Binney & Son				2·65	11·00		7·00	18·00			6 15 0
Blood and Bone and Super.	128	do.	do. do.				1·75	10·00		13·00	23·00			6 15 0
Bonedust and Super.	130	do.	do. do.				1·25	5·00	....	10·00	15·00	....	1·25	5 0 0
B.S.P., No. 1	132	do.	do. do.	....	....	....	2·00	5·00	....	10·00	15·00	....	1·25	5 12 6
Do. No. 2	133	do.	do. do.	....	....	....	3·00	5·00	....	10·00	15·00	....	1·25	6 5 0
Do. No. 3	134	do.	do. do.	....	....	....	1·25	5·00	....	10·00	15·00	....	2·50	5 15 0
Do. No. 4	135	do.	do. do.	....	....	....	1·25	5·00	....	10·00	15·00	....	5·00	6 10 0
Do. No. 5	136	do.	do. do.	....	....	....								

* Price on application. † Contains 5·75% MnO_2 (Manganese dioxide). ‡ On rails, Perth.

AN INVESTIGATION INTO THE COMPOSITION OF WESTERN AUSTRALIAN WHEAT BELT PASTURES AND STUBBLES.

By E. J. Underwood,[1] F. L. Shier[2] and R. J. Harvey.[3]

Very heavy losses of sheep have occurred annually from the disease botulism (Toxic paralysis) throughout the Wheat Belt of Western Australia. This disease occurs in sheep only during the long dry summer period from November to May and disappears rapidly with the advent of winter rains and green feed. It is caused by many of the sheep developing a depraved appetite or pica which impels them to consume rabbit carcases and other carrion infected with the toxin of *Clostridium botulinum* (Bennetts 1933). Although the pica is undoubtedly associated with the poor grazing conditions of the summer months its exact cause is not at present known. The experiments of Underwood and Shier (1935, 1936) have shown, however, that the pica is not due to a direct deficiency either of phosphorus or of protein. Collateral with these experiments an investigation into the composition of the pastures and stubbles of the Wheat Belt was undertaken to see if any light could be thrown upon the problem. It was felt that the results obtained, even if yielding little of value in connection with the control of botulism, would be of considerable value in regard to stock and pasture management in the areas concerned.

Previous Investigations.—Although a considerable number of analyses of pastures are available from the Dairy Belt of Western Australia, which has a comparatively high rainfall incidence and short dry period, little information has been obtained of either the botanical or chemical composition of the grazings of the drier Wheat Belt. Underwood (1928) carried out a rough survey of the pastures over a wide section of the agricultural areas which included samples from the fringes of the Wheat Belt. He found the reported "good" quality pastures to have in general much higher proportions of clovers, of protein and of phosphorus than the "poor." Even the "good" pastures, however, were much lower in protein and phosphorus contents than average English cultivated pasture as reported by Orr (1928). Considerable stimulation of clovers and increase in percentages of protein and phosphorus was found in pasture plots fertilised with superphosphate. Some analyses of pastures at Beverley, on the fringe of the Wheat Belt, were also carried out by Allsop (1930 unpublished data). He found a gradual fall in the protein and phosphorus content of the herbage between July and December.

Present Investigation.—To avoid difficulties of collection and of interpretation of data from too wide an area it was decided to confine sampling of pastures and stubbles to three districts in the central Wheat Belt. Accordingly samples were obtained from two separate farms in each of the Goomalling, Meckering and Kellerberrin districts at five different growth stages over a two-year period beginning in October, 1933. These stages were as follows:—

Pastures:—June-July—young, green and short.
August-September—green to full grown.
October—just maturing, partially dry.
December-January—dry and mature (with seed).
March-April—dry, seeded, weathered and grazed.

Wheat Stubbles.—December—highly selected samples of seeds, seed heads and bottom growth.

In view of the marked powers of selective grazing which sheep display, the samples were selected to conform, as far as could be judged, to the material actually consumed by the sheep rather than to the whole material available. This be-

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came especially important in the later growth stages where the dry fibrous stalks which constituted the main bulk of the herbage were not consumed at all.

Soil and Climatic Conditions.—The samples of pastures and stubbles were obtained from poor sandy types of soils situated in the brown earth zone. No analytical data as to the plant food status of these soils are available though manurial trials with cereals in these areas would indicate a very low content of available phosphorus.

The climate of the three districts investigated is characterised by the long hot dry summers and mild moist winters. The rainfall is scanty and almost entirely restricted to the winter months. The monthly rainfall figures for 1933, 1934 and 1935 are given in Table 1.

The dry period was much shorter than usual in the first season owing to the abnormally heavy rains of March, 1934. The following summer was, however, characterised by a very long and severe dry period. The winter rains did not set until June, 1935.

General Notes on the Pastures Studied.—Quantitative studies of either the seasonal productivity of the pastures or their botanical composition were not undertaken, though careful observations were made throughout, from which a number of significant conclusions could be drawn.

The outstanding features of the pastures observed were, firstly, their extremely low productivity, and secondly, the very low proportion of clovers of any size which they contained. The low productivity is due primarily to climatic factors, particularly the long dry summer and the cold temperatures which normally prevailed during June and July when active growth should be taking place. These factors are, of course, uncontrollable but the very general neglect of any form of pasture improvement by fertilisation, and by the introduction of better plant species, and the consequent almost entire absence of any good productive species, which could take full advantage of the growing conditions which do exist, is also a strong contributory factor. This applies particularly to the "clovers" which, except for small fertile areas where Burr Trefoil (*Medicago denticulata*) sometimes makes very good growth, are restricted to small specimens of such poor and "stemmy" species as woolly clover (*Trifolium tomentosum*) and Cluster clover (*T. glomeratum*), etc. It was found also that in many of the pastures the flat and watery Capeweed (*Cryptostemma calendulaceum*) made up as much as 100 per cent. of the herbage. This species is very palatable and frequently produces quite a bulk of green material, but it dries off exceedingly quickly with the first sign of summer, and in the dry period in the absence of supporting legumes is very low in protein content.

Methods of Analysis.—Nitrogen was determined by the standard Kjeldahl method and the factor 6.25 used for converting it to protein. Calcium was determined by permanganate titration and phosphorus colorimetrically on the ash. Ashing was carried out at a dull red heat in the presence of added $Mg(NO_3)_2$. Frequent checks using the volumetric molybdate method after wet digestion showed this method to be quite satisfactory.

Crude fibre was determined by the standard method.

Results.—The results for protein, phosphorus and calcium expressed as percentages on the dry matter of the samples are given for both pastures and stubbles in Table II. The analyses of the individual samples from the three areas studied showed no differences which could be correlated with the different areas. Consequently the results for all the pastures from these districts at each period of sampling in each season are grouped together.

Crude Protein.—The most noteworthy feature of the crude protein figures is the regular fall from fairly high average values in June and July, when the pas-

tures are green and short to very low average values as the pastures mature. This fall is equally obvious in both seasons and is evidently normal for this type of annual pasture. Only in the first two months of the growing season does the protein content compare at all favourably with that of English cultivated pastures, and even at that time some of the pastures sampled are extremely low. For the rest of the year the pastures must, with one or two exceptions, be considered as deficient in protein. The exceptions, such as samples 39 and 73 in the August-September period, 42 in the October period and 54 in the December-January period, in all cases contained significantly higher proportions of legumes in their make-up. There is little doubt that the very small proportion of productive legumes is the principal factor inducing the low protein values in the Wheat Belt pastures. The high proportion of Capeweed is probably also an important factor since samples 40, 48 and 50 which are lower in protein than the others in their groups consist entirely of Capeweed. The ability of increased proportions of a legume to raise the protein content of the herbage is further illustrated by the sampling of a certain small area of pasture in the Goomalling district, which consisted almost entirely of green Burr Trefoil. This pasture contained 23.27 per cent. crude protein in the dry matter.

Phosphorus.—An examination of the phosphorus figures shows that at no time can the pastures be considered rich in phosphorus, as judged by overseas standards. During the first four or five months of the growing period there appears to be little change in the proportion of phosphorus present. Thereafter a decided decline takes place until in the dry, weathered herbage of March and April the values are very low indeed and can only be compared with those of the phosphorus-deficient areas of the South African Veldt. These statements apply equally to both of the seasons studied, though in March, 1934, the phosphorus levels are lower than in the corresponding period of 1935. This is probably explained by the heavy storms which may have affected the dry herbage early in March, 1934.

Calcium.—In contrast to the protein and phosphorus figures the calcium content of the pastures is extremely high, and in the 1933-1934 season remains high throughout. In 1934-35 the calcium values are not only high at the commencement of the season but actually rise further to extremely high levels during the dry period. The high calcium content of these pastures is surprising in view of the low proportion of legumes present. A similar finding was made in connection with W.A. pastures by Underwood (1928). A rise in calcium levels of herbage due to maturity and drought, in contrast to the marked falls in phosphorus and protein under the same conditions has been previously noted by Woodman and Underwood (1931) and by Dunne (unpublished data) though values as high as those in April, 1935, are extremely unusual. These particular samples consisted almost entirely of dry Capeweed. It would be of great interest to study this species separately to ascertain just what conditions are conducive to such high calcium concentrations.

Crude Fibre.—A selection of the samples were analysed for crude fibre. The results are given in Table III.

As would be expected from the increasing maturity of the pasture species there is a general rise in fibre content from June to December. Considerable individual variation is evident but only in the young green stage in June and July can the pastures be considered other than high in fibre.

Wheat Stubbles.—A number of highly selected samples of wheat stubbles were obtained before any grazing had taken place. These contained a high proportion of broken ears, grain and "flag" or leaf and very little of the straw which is not eaten. These were analysed for protein, calcium and phosphorus and a number of them for crude fibre. The results are given in Tables II and III.

The protein content of these samples is fairly constant and is closely similar to that of the dry pastures of December and January. It is evident that the turning of sheep into fresh stubble at this time will not, in general, appreciably improve their protein intake, except where there is a high proportion of unthreshed heads which are selected by the sheep. The phosphorus intake will, however, be somewhat improved on the average.

The calcium percentages are very variable and in some cases comparatively low. This is, no doubt, due to the high proportion of grain in the samples but can hardly be considered of any nutritional importance in view of the high intake of this element during the greater part of the year.

The fibre content of the three samples of stubble analysed shows this selected material, although dry, to be very much less fibrous than the dry pasture of the summer months. It would, therefore, represent a much better source of available energy to the grazing animal than the pasture of the latter half of summer.

Discussion.—The results indicate very clearly that the Wheat Belt pastures are exceedingly poor both in quality and quantity. The low phosphorus values which exist for about half the year are apparently of little significance in sheep husbandry since it has been shown very definitely by Underwood and Shier (1936), that no deficiency is normally present in sheep grazing on such pastures, even when no phosphatic lick, or summer supplementary feeding, is practised. It is probable, however, that many of the pastures must be considered deficient in phosphorus for cattle at least during the summer months. Some very low values for the inorganic blood phosphorus of milking cattle were obtained on Wheat Belt farms in the summer of 1935-36 (Underwood—unpublished data).

The low protein values of the pastures which exist for eight to nine months of the year must be considered as limiting factors for the productivity of both sheep and cattle. These low figures are associated primarily with the long dry period but there is no doubt that they could be markedly raised by the development of more and better legumes. The introduction of the "Dwalganup" strain of Subterranean clover at least in the 15-20 inch rainfall area of the Wheat Belt would, with suitable phosphatic fertilisation, result in a tremendous improvement in the quantity and quality of the grazing. This has been already accomplished at Muresk by Dr. T. C. Dunne and suggestions for a modified rotation for the Wheat Belt based on an active programme of pasture development have been already published by Dunne and Shier (1934).

Summary and Conclusions.—A study of the pastures in three areas typical of the Western Australian Wheat Belt has been made over a two-year period.

The outstanding features of these pastures were their low productivity and their low protein content for about eight or nine months of the year. The phosphorus content of the herbage was also low for the greater part of the year. The calcium figures remain exceptionally high, however, in almost every case.

The low productivity and the low content of protein and phosphorus is associated primarily with the long dry period. The almost entire absence of any good quality productive pasture legumes is thought however, to be a strong contributory factor.

REFERENCES.

Bennetts, H. W. (1933) Journal Commonwealth C.S.I.R. 6, p. 137.
Dunne and Shier (1934) Journal Department Agriculture, W.A. 11, p. 254.
Orr (1928) Minerals in Pastures, Chap. 2, p. 10.
Underwood (1928) Thesis submitted for Degree of B.Sc. (Hons.) University of W.A.
Underwood and Shier (1935) Journal Department Agriculture, W.A., 12, p. 277.
Underwood and Shier (1936) Aust. Jnl. Expt. Biol. and Medical Science, XIV, p. 77.
Woodman and Underwood (1932) Journal Agricultural Science XXII, Part 1, p. 26.

TABLE I.

Year.	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total for Year.
MECKERING.													
1933	16	....	52	28	291	284	194	175	77	170	11	....	1,298
1934	75	21	311	370	153	288	246	99	93	12	107	10	1,785
1935	67	44	26	72	86	177	273	211	92	91	....	10	1,149
Average 38 years....	29	45	75	85	202	284	304	224	131	107	43	31	1,612
GOOMALLING.													
1933	21	17	15	9	288	365	168	261	74	132	30	5	1,385
1934	138	67	257	251	132	292	187	152	83	23	84	15	1,681
1935	75	110	17	85	64	144	219	223	74	47	3	4	1,065
Average 24 years....	45	51	75	79	174	265	279	202	117	92	44	39	1,465
KELLERBERRIN.													
1933	29	3	27	27	206	261	143	163	79	126	43	3	1,110
1934	68	15	294	342	89	160	244	152	61	8	92	19	1,544
1935	86	93	52	71	36	106	270	195	78	157	6	9	1,159
Average 43 years....	35	42	104	106	167	221	222	176	114	86	40	54	1,343

TABLE II.

COMPOSITION OF PASTURES AND STUBBLES.

Percentages on Dry Weight Basis.

	1933-34.			1934-35.			
	Protein.	P_2O_5.	CaO.	Protein.	P_2O_5.	CaO.	
June-July— Pastures young, green and short	(26) 17·50	0·51	2·16	(70) 17·90	0·42	1·40	
	(27) 10·00	0·31	1·24	(67) 15·63	0·44	1·17	
	(29) 15·98	0·55	1·73	(68) 19·52	0·64	1·94	
	(30) 19·80	0·74	1·66	(71) 16·92	0·48	1·43	
	(31) 15·88	0·72	1·68	(72) 15·05	0·38	1·41	
	(32) 8·66	0·41	1·16				
Mean	14·64	0·54	1·61	17·00	0·47	1·47	
August-September— Pastures green but full grown	(38) 6·40	0·44	1·61	(75) 13·42	0·55	1·64	
	(39) 18·23	0·64	1·68	(76) 12·09	0·54	1·61	
	(36) 15·61	0·79	1·40	(77) 11·94	0·58	1·71	
	(37) 10·61	0·62	1·45	(73) 16·94	0·62	0·80	Fair percentage clovers short and grazed.
	(34) 11·72	0·71	1·30				
	(35) 11·60	0·53	1·49	(79) 8·22	0·50	1·34	Mainly cape weed, bulky, *i.e.* not grazed.
Mean	12·36	0·62	1·49	12·52	0·56	1·42	
October— Pastures just maturing, partially dry	(2) 9·31	0·46	0·92	(44) 9·83	0·50	1·71	
	(3) 9·94	0·44	1·26	(45) 7·43	0·40	2·30	
	(4) 8·11	0·33	1·04	(42) 12·68	0·46	1·93	Highly selective sample containing large percentage dry trefoil and burr.
	(5) 8·31	0·41	1·08	(43) 8·42	0·50	1·90	Practically all cape weed, no clovers.
	(7) 11·25	0·48	1·96	(40) 5·22	0·22	2·42	
	(8) 9·08	0·48	1·18	(41) 8·46	0·29	2·14	
Mean	9·33	0·43	1·24	8·68	0·40	2·07	
Dec.-January— Pastures dry and mature (with seed)	(13) 10·62	0·30	0·84	(54) 13·28	0·41	1·46	Mainly cluster clover.
	(17) 8·62	0·28	0·97	(56) 9·24	0·33	2·02	
	(15) 7·42	0·23	1·08	(52) 8·64	0·27	2·24	
	(24) 6·00	0·25	0·74	(58) 8·71	0·26	2·18	
	(19) 7·19	0·25	2·02	(48) 4·70	0·16	2·43	} Samples mainly cape weed.
	(20) 6·31	0·25	1·95	(50) 5·46	0·23	2·98	
Mean	7·76	0·26	1·27	8·34	0·28	2·22	
March-April— Pastures dry-seeded and weathered				(62) 3·07	0·20	3·10	
	(21) 3·62	0·11	0·44	(61) 2·78	0·15	2·44	
	(22) 3·25	0·15	1·31	(66) 6·70	0·23	2·87	
	(25) 4·85	0·12	0·52	(59) 5·77	0·22	2·39	
				(60) 3·17	0·25	2·73	
Mean	3·91	0·13	0·76	4·30	0·21	2·71	
December— Wheat stubble highly selected				(53) 9·86	0·56	0·45	
	(12) 7·38	0·41	1·11	(55) 7·52	0·29	1·78	
	(16) 6·75	0·32	1·26	(51) 6·14	0·32	0·80	
	(18) 6·75	0·35	0·66	(57) 6·05	0·20	1·06	
				(47) 6·90	0·40	0·56	
				(49) 9·62	0·49	0·45	
Mean	6·96	0·36	1·01	7·68	0·38	0·85	

TABLE III.

CRUDE FIBRE DETERMINATIONS—1933-34 AND 1934-35.

Percentages Stated on a Dry Matter Basis.

June-July—			
Pastures young, green and short ...	(29)	15·0	Mean—12·4
	(67)	7·7	
	(26)	13·2	
	(31)	13·5	
August-September—			
Pastures green but full grown ...	(77)	19·2	19·2
October—			
Pastures just maturing, partially dry	(4)	28·3	Mean 24·7
	(43)	19·8	
	(2)	25·6	
	(8)	24·9	
December-January—			
Pastures dry and mature (with seed)	(15)	25·9	Mean 24·0
	(52)	28·2	
	(17)	22·4	
	(19)	19·6	
March-April—			
Pastures dry-seeded and weathered	(21)	22·4	Mean—24·7
	(22)	29·4	
	(61)	22·2	
Wheat Stubbles—			
Highly selected samples	(16)	18·5	Mean—17·4
	(57)	18·4	
	(47)	15·4	

BORDEAUX MIXTURE FOR HOME GARDENS.

H. A. J. PITTMAN, B.A., B.Sc. Agr. (Hons.), Dip. Ed., Plant Pathologist.

As many requests are being received for information as to the preparation of Bordeaux Mixture in small quantities for use in home gardens, it is felt that a part of the article on this subject which appeared in this Journal for December, 1935, pp. 410-427, could be republished with advantage.

The whole subject of Bordeaux Mixture was dealt with in detail in the pages mentioned, and information required on aspects not appearing herein should be obtained from that source or from Leaflet 314 (1936 edition).

DIRECTIONS FOR PREPARING BORDEAUX MIXTURE IN SMALL QUANTITIES FOR HOME GARDENS.

A small quantity of Bordeaux Mixture of 4-4-40 formula can be prepared by taking:—

(1) 4 ozs. bluestone,

(2) 4 ozs. "freshly burnt," "stone," or "quick" lime,

and making up to a final volume of 2½ gallons as indicated below*:—

a. **Dissolve the 4 ozs. of bluestone in a wooden tub or wooden barrel, or a copper, bronze, brass, glass or earthenware vessel, using 1¼ gallons of water.** The bluestone may be dissolved by suspending it overnight in the water in a

* If approximately 4-4-50 Bordeaux Mixture (actually 4-4-48) is to be made, the final volume will be three (3) gallons instead of two and a half (2½). In this case the same amounts of bluestone and quick lime are required, but each amount should be "dissolved" in 1½ gallons instead of 1¼.

piece of hessian, bagging, or linen, from a stick placed across the mouth of the receptacle; or by heating the water and pouring it over the bluestone in the bottom of the receptacle, if the mixture is required in a hurry. Bluestone "fines" or "snow" may be used with advantage instead of the usual large crystals, as they dissolve quite readily in cold water, on gentle agitation.

b. **Slake the 4 ozs. of quicklime, which must be in lumps, quite fresh and of good quality, in another container, by adding water a little at a time.** A small wooden cask is convenient, but, unlike the bluestone, an iron vessel such as a clean empty kerosene tin may be used in which to slake the lime. **When slaked, make up to 1¼ gallons with water.** This suspension and partial solution of lime in water is known as "milk of lime."

c. **Pour the two liquids simultaneously through a copper, brass or bronze wire strainer into the spray outfit, or into a wooden or other non-corrosible container, and, after seeing that the volume is exactly two and a half gallons, use immediately.**

Fig. 1.—A type of knapsack sprayer suitable for use on small areas. Note the Spring Lever Tap (Trigger Grip Control) with which the spray can be released or stopped instantly. The liquid capacity is 3¾ gallons. Such a machine can be obtained with a copper tank for spraying with Bordeaux Mixture; made of special brass alloy for spraying, in addition, with Lime Sulphur or similar sulphides; or with all parts lead-coated for spraying with acids such as Sulphuric Acid, as used for the control of "anthracnose" of grapes, etc.

(After "Vermorel Eclair Export Catalogue," No. 22, 1932.)

An alternative method is to pour the bluestone solution into the spray outfit, and then pour in the milk of lime, through a piece of bagging or calico, to remove any gritty particles, sand, or lumps which might clog the sprayer, keeping the bluestone solution well agitated while doing so. See that the final volume is correct and commence to spray immediately.

The bluestone solution and the milk of lime can be kept indefinitely, so long as they are kept separate and any evaporated water is replaced to each before using; but once they have been added to each other the spraying must be commenced immediately and continued until all the spray is used up, as Bordeaux mixture soon deteriorates if left standing without constant agitation after being made up.

Never mix the solid lime and bluestone together before adding the water. The more dilute each constituent is before meeting the other, the better.

STOCK SOLUTIONS AS A MEANS OF REMOVING THE DRUDGERY FROM THE FREQUENT PREPARATION OF BORDEAUX MIXTURE.

It rarely happens that a single spraying is sufficient to control a disease in plants. Even in those cases where a single spraying carried out at the right time does suffice, as with "Shot-hole" of stone fruits in many places, or "Peach Leaf Curl," the orchardist usually finds that the different varieties are not all ready for spraying at the same time. This usually means that the spraying period is pro-

tracted and the grower becomes impatient at having to continually make up "from scratch" a fresh lot of spray. Frequently, also, a grower finds, on going to use his quicklime, that it has become air-slaked, with the result that a new lot of quicklime must be ordered for delivery in a hurry. This often causes fraying of tempers, and there is always the possibility of a lot of damage being done by disease, in the meantime, before the new lot arrives. A certain amount may be used out of the new consignment, and again deterioration may take place by the time the remainder is required.

Difficulties of the above nature may readily be avoided if the growers will appreciate the following facts:—

Although, when once prepared, Bordeaux Mixture must be used immediately, the separate ingredients, i.e., the bluestone and the lime, can be kept in concentrated form in water for very long periods without deterioration taking place, and ready for use at a moment's notice.

METHOD OF MAKING UP STOCK SOLUTIONS OF BLUESTONE AND QUICKLIME WHEN ONLY VERY SMALL QUANTITIES OF BORDEAUX MIXTURE WILL BE USED AT ANY ONE TIME.

Where Bordeaux Mixture is required for use in small flower-gardens or small-scale vegetable gardens it can most conveniently be prepared in quantities of about 2½ to 3 gallons as indicated above.

To minimise trouble and save a considerable amount of time, in the aggregate, a good plan is to weigh out on the one occasion a large number of batches of bluestone "fines" or "snow," each batch weighing 4 ounces. Each 4-ounce lot is then dissolved in a bottle containing about a quart of water.

If preferred, the bluestone may be weighed out in one-ounce lots, each ounce being placed with water into an 8-ounce medicine bottle or bottle of similar size.

In connection with the lime, as soon as possible after purchase, the "quick lime" should be broken down with a hammer, taking care to avoid injury to the eyes from flying particles. The broken pieces are then weighed out into units of 4 ounces each. Each unit of 4 ounces is then separately slaked, with a minimum of water, in a metal container. When it has cooled down somewhat, each 4-ounce lot is run through a metal funnel into a large bottle containing about 2 inches of water, and additional water is added through the funnel until the bottle is almost full.

As in the case of the bluestone, the lime stock "solutions" may be made up in one-ounce lots, if preferred, the ordinary eight-ounce medicine bottle being used to hold one ounce of quicklime plus a small quantity of water.

STORAGE OF THE STOCK "SOLUTIONS."

Both the bluestone and quicklime "solutions" in bottles can now be stored indefinitely until required for use in making up the Bordeaux Mixture. It is desirable that the bottles containing the lime should be corked, but apart from the possibility of the bottles being upset this is not important in the case of the bluestone.

SLAKING OF QUICKLIME IN A METAL FUNNEL.

A very satisfactory way of slaking the 4-ounce or 1-ounce quantities of broken quicklime is to take a cheap tin funnel with a diameter of approximately six inches, and with a spout of a diameter small enough to pass easily into the neck of a "six-to-the-gallon" or quart bottle. A rubber stopper is used to temporarily block up the aperture at the top of the spout. To provide a means of withdrawing the stopper when required, a piece of wire should be fixed through its centre. The

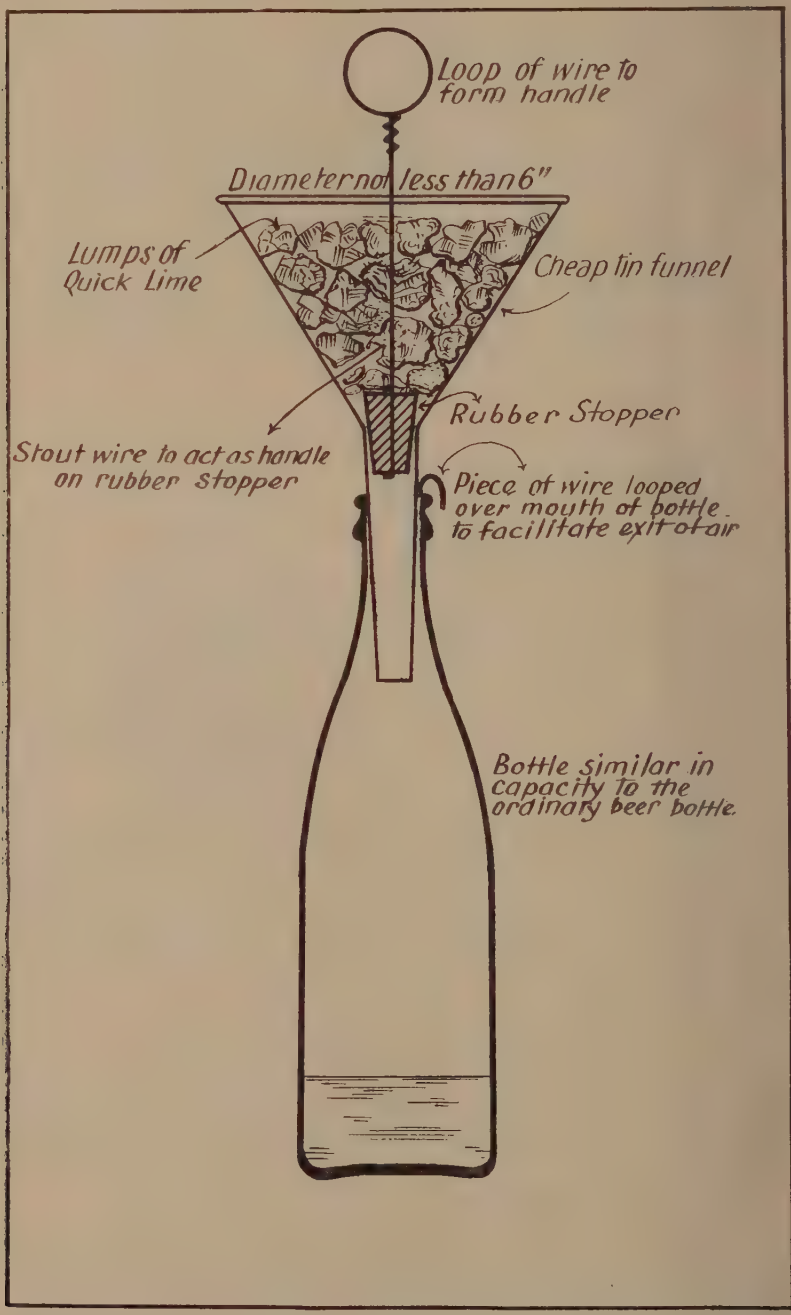

Loop of wire to form handle
Diameter not less than 6"
Lumps of Quick Lime
Cheap tin funnel
Rubber Stopper
Stout wire to act as handle on rubber Stopper
Piece of wire looped over mouth of bottle to facilitate exit of air
Bottle similar in capacity to the ordinary beer bottle.

Fig. 2.—Diagrammatic representation of method of slaking quick lime in small quantities, such as 4-ounce lots, in a metal funnel, prior to running into "six-to-a-gallon," or quart, bottles, for storage purposes. For full explanation of the technique see text. A cork may be used instead of a rubber stopper, but is not so satisfactory, as it is attacked by the caustic properties of the hot lime.

(Drawing by courtesy of Chief Draughtsman, Lands Department.)

broken quick lime is packed in the funnel round the wire, and on top of the rubber stopper, in lots of 4 ounces, or one ounce, as the case may be, at a time. The lime is slaked in the funnel with a small quantity of water, and when slaking is complete the rubber stopper is gently raised from the top of the spout by means of the wire. This allows the slaked lime to run, with the help of additional water, into the bottle below. Two inches or so of water placed in the bottle before commencing to slake the lime will prevent the cracking of the glass as the hot slaked lime runs into it. A piece of fine wire bent over the neck of the bottle so as to make an air space between the side of the bottle and the spout of the funnel will allow the slaked lime to enter the bottle and the air to escape without trouble. (See Fig. 2 for diagrammatic representation of the above-described technique.)

PREPARATION OF BORDEAUX MIXTURE FROM THE STOCK "SOLUTIONS."

To make a small quantity of Bordeaux Mixture of 4-4-40 strength, all that now remains is to take one bottle of bluestone concentrate containing four ounces of bluestone, and one bottle of lime concentrate containing four ounces of lime, pour each into a separate container and add sufficient water to bring both solutions to 1¼ gallons each. The lime should be thoroughly shaken before pouring from the bottle so as to incorporate the sediment with the clear liquid above it.

The diluted bluestone and diluted quick lime "solutions" are then poured simultaneously together, and the Bordeaux Mixture is ready for use.

TEST FOR BORDEAUX MIXTURE BEFORE USING.

Bordeaux Mixture is said to owe its valuable fungicide properties to a basic copper sulphate from which the ordinary copper sulphate is re-formed in very small quantities from time to time. These quantities are too small to harm the tissues of most plants, but are yet quite sufficient to kill the germinating seed bodies (*spores*) of harmful fungi. If, by some mischance, there should happen to be too little lime in the Bordeaux Mixture to completely turn the bluestone into the insoluble basic sulphate, considerable injury could be caused to any plants sprayed. While there should be very little likelihood of this happening if ordinary care is taken, each lot of Bordeaux Mixture made up should be tested, before using, by dipping the clean blade of a penknife or a bright piece of iron such as a recently filed shiny nail into the mixture for several minutes. If the mixture does not contain sufficient lime, a reddish-brown deposit of copper will form on the iron and more lime should be added. *Always use a little too much lime rather than a little too little*, as quite a considerable excess of lime may be used without the fungicidal properties of the spray being markedly lowered, and most plants are much more tolerant of an excess of lime on their foliage than they are of an excess of bluestone.

DEVELOPMENT OF EXPORT TRADE IN PIG PRODUCTS.

For a number of years the Department, when making recommendations regarding the development of an export trade in pig products, has pointed out that, as far as Western Australia is concerned, Great Britain offers the only large market, although a limited trade is being developed with the Near East and Singapore.

It has been pointed out that the British market, although apparently considerable in extent, is only so if consideration is given to the bacon trade rather than the pork supply.

The British pig farmer being on the spot prefers to concentrate on the pork market and can command a high price for his fresh product compared with the imported chilled or frozen pork carcases. Moreover, this pork market is a seasonal one, fluctuating considerably in volume and, therefore, an unsafe one for overseas producers.

The demand for bacon, on the other hand, does not fluctuate as does that for pork. The bacon trade is approximately twelve times the volume of the pork market, and, as West Australian bacon carcases can be exported "green" to be finally cured in Britain, they are in a better position to compete with the English *bacon* carcases.

This latter market is thus peculiarly suited to Western Australia with its large supplies of cheap grain and dairy by-products.

This policy has now been confirmed by a resolution from the Australian Meat Board at their last meeting, which reads as follows:—

> "That the Board considers that the best way to export pig products from Australia to the United Kingdom is in the form of frozen baconer carcases and pieces suitable for manufacture into bacon and hams, and recommends accordingly to producers."

This resolution was passed as the result of a report dated 26th February, 1937, on the "Market for Bacon Pigs in the United Kingdom," by Mr. R. G. Watson, Chairman of the Council of the Australian Pig Industry, and the representative of the Australian Pig Producers on the Meat Board. Mr. Watson stated that, in view of the preference of the British pig farmer to cater for the pork trade, he considered that future restrictions, if any, on Empire pig meats are more likely to be placed on porkers than on baconers, particularly as during last year the British pig-raiser was unable to supply more than 50 per cent. of the requirements for factories curing British bacon.—G. K. Baron-Hay, Superintendent of Dairying.

ASSOCIATIONS FOR THE IMPROVEMENT OF DAIRY HERDS IN WESTERN AUSTRALIA.

REPORT FOR YEAR ENDING 30th APRIL, 1937.

G. K. Baron-Hay,
Superintendent of Dairying.

During the past year in common with all other dairying districts in Australia, the season has been an unfavourable one in this State for the production of dairy produce, owing to the unusually dry winter from May to November 1936, followed by four months of almost total drought.

In spite of these unfavourable conditions, however, those Associations, in which cows had been under test for more than one year, showed a slight increase in production from 207 lbs. to 210 lbs. butter fat per cow as indicated in the following Table:—

Table 1.

*Average Production per Cow.**

A = Average of Units tested more than 1 year.
B = Average including 8 new Units.

	No. of Cows*	Milk. Gals.	Test. %	Butter fat. lbs
A	4,649	463	4·53	210·06
B	8,569	434	4·53	196·74

* Does not include Cows tested less than 100 days.

Total Number of Cows tested = 9,115
Total Number of Herds tested = 356

During the year the number of associations was increased from nine to 18, which is a safe indication that the Scheme is supplying information to farmers, which is considered by them to be of importance. This extension of the Scheme has been made possible by an increased grant from the Rural Credits Branch of the Commonwealth Bank and supplemented by the State Government.

It is interesting to notice the higher average production in the nine older Units compared with that of the nine Units which have only been formed for one year; the older Units show an average production of 210 lbs. butter fat per cow, while the newer Units record only 181 lbs. per cow.

It is significant also that, at the end of the first year from the inception of the Scheme, the average production of the cows tested was practically the same as in the 9 new Units, namely 183 lbs. butter fat per cow. (See Table 2.) There are other grounds for believing that this is the average test of those cows outside the Scheme in the South-Western dairy belt. If a system of Herd Recording could be introduced to embrace all herds in the dairying districts instead of only 356 herds as at present, a similar increase to that obtained by those herds under test would mean an increase in revenue of approximately £175,000 to our dairy farmers at last year's average price for butter fat, i.e., 1/2½ per lb.

TABLE 2.

Average Production per Cow, 1934–1937.

Year.	No. of Cows.	Milk.	Test.	Butter fat.
		Gals.	%	lbs
1933–34	4,038	415	4·35	180·6
1934–35	4,088	456	4·56	207·8
1935–36	4,590	459	4·51	207·3
*1936–37	9,115	434	4·53	196·7

* Includes 9 Associations testing herds for only one year.

Mr. S. GRAY'S GRADE JERSEY HERD OF 44 COWS AT PEMBERTON.

Mr. Gray commences milking in April each year; this herd is carried on the 160-acre farm, all of which is cleared.

Table 3 below, which gives the average production of the cows in each Association, shows that the majority of the older Units increased their average production notwithstanding the unfavourable season. The productions in the new Units, however, approximate those which the older groups showed during their first year in the Scheme.

These results are encouraging and have been achieved not only by the culling of the obviously unprofitable cows but by improved herd management such as avoiding over-stocking, more generous conservation of fodder, and particularly controlled mating, so as to ensure cows commencing their lactation early in autumn.

Table 3.

Average Production of Cows in each Unit.

Unit.	Herds.	Cows.	Heifers.	Milk.	Test.	1936–37. Butter-fat.	1935–36. Butter-fat.
	No.	No.	%	lbs	%	lbs	lbs
A. Donnybrook ...	20	410	23	4,575·4	5·15	235·79	265·1
B. Serpentine ...	16	393	14	5,134·8	4·2	215·92	204·5
C. Cookernup ...	20	522	...	4,729·6	4·12	195·23	191·9
D. Harvey ...	20	488	22	4,597·4	4·70	216·08	214·0
E. Brunswick ...	20	623	18	5,033·0	4·59	231·32	217·2
F. Dardanup ...	24	723	21	4,030·5	4·48	180·73	168·2
G. Capel	13	542	15	4,793·9	4·36	209·96	221·1
H. Balingup ...	21	528	14	4,442·3	4·79	212·78	196·3
I. Forest Grove ...	22	420	17	4,519·5	4·48	202·43	206·0
J. Pemberton ...	20	446	9	3,984·2	4·52	180·20	...
K. Rosa Brook ...	23	428	9	4,197·8	4·66	195·89	...
M. Manjimup ...	21	447	11	3,950·0	4·50	178·80	...
N. Uduc	14	290	16	4,524·3	4·15	187·66	...
O. Benger	18	609	18	4,529·9	4·51	208·14	...
P. Pinjarra ...	21	490	14	3,570·8	4·55	162·66	...
Q. Greenbushes ...	20	573	4	3,649·0	4·66	170·47	...
R. Brookhampton...	20	282	22	3,769·0	4·78	180·43	...
S. Albany ...	22	355	20	3,740·0	4·27	161·95	...

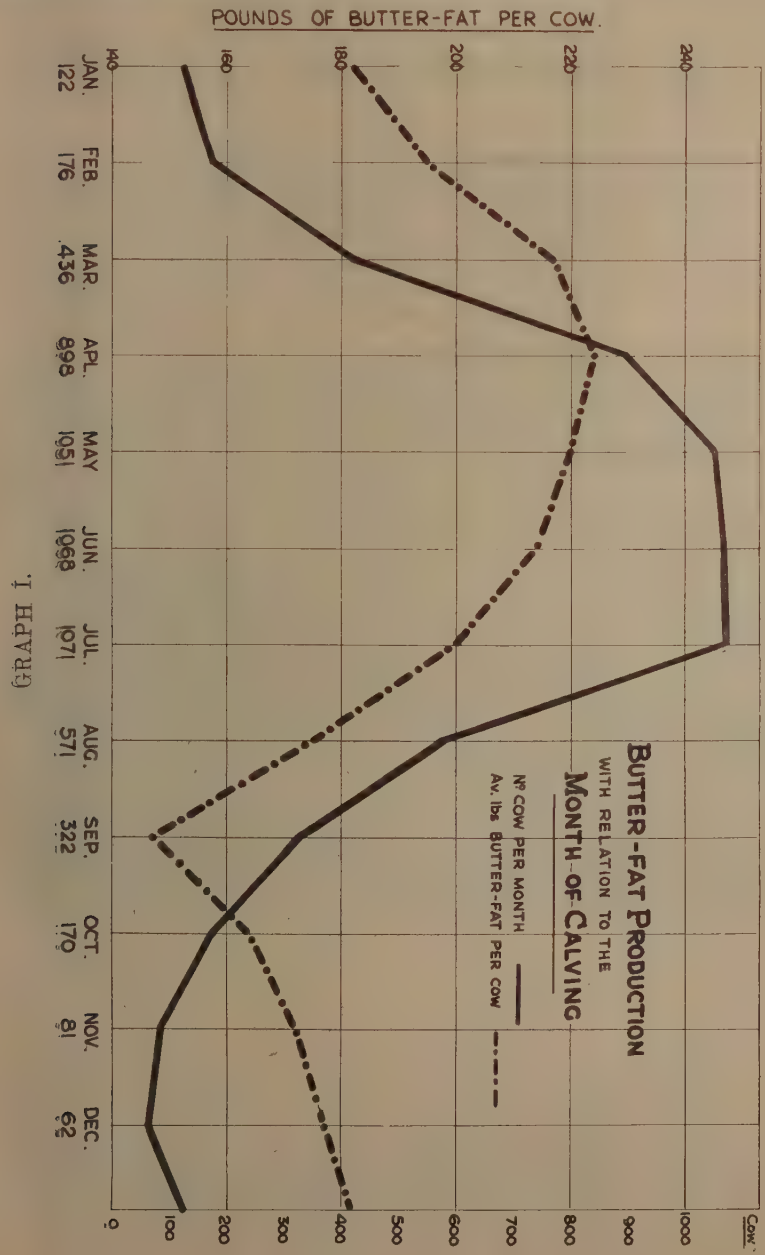
The handicap which is placed on cows which commence their lactation late in the season is shown in Table 4, where the production of cows calving in May and June is shown against the average of all cows in the Unit. In most instances, it will be seen that those Units having the higher percentages of "early calvers" also show the higher average productions.

Table 4.

Percentage of Cows completing Nine Months' Test.

Unit.	Cows.	Average Butter-fat.	Unit Average.
	%	lbs	
A. Donnybrook ...	87·0	241·49	235·79
E. Brunswick	78·21	238·15	231·32
D. Harvey	55·32	222·75	216·08
B. Serpentine	54·54	251·41	215·92
H. Balingup	76·07	224·31	212·78
G. Capel	77·02	217·78	209·96
O. Benger	90·47	212·36	208·14
I. Forest Grove ...	55·71	218·81	202·43
K. Rosa Brook ...	45·60	221·78	195·89
C. Cookernup	56·80	207·80	195·23
N. Uduc	48·55	209·81	187·66
F. Dardanup	53·29	199·72	180·73
R. Brookhampton ...	80·90	194·28	180·43
J. Pemberton ...	63·0	192·63	180·20
M. Manjimup	61·23	194·98	178·80
Q. Greenbushes ...	83·0	170·94	170·47
P. Pinjarra	77·11	187·94	162·66
S. Albany	27·60	180·77	161·95

An indication of the most profitable period in which to commence lactation is given in the following Graph 1, which shows the average production of those cows which calved in each month. It will be seen that the greatest production is obtained from those cows which calve during March to June inclusive, after which there is a definite handicap against the cow to produce to her capacity.



GRAPH 1.

The graph also shows that last year the greatest number of cows calved during July—a considerable improvement on previous years. There is a definite trend towards "earlier calving," which probably will be continued until the majority of cows have commenced their lactation periods by the end of May.

Success in this, however, calls for very careful management, particularly as regards—

1. Control of the dairy sire.
2. Prevention and treatment of disease.
3. Provision of suitable fodder.

1. *Control of the Dairy Sire.*

Success in regulating the lactation period can only be assured where the sire is held in a separate bull paddock until required for mating. The common practice of allowing the bull to run with the herd is fast disappearing, as, apart from having no control over services, the larger herds of from 40 to 60 cows now commonly found necessitate strict control, unless more than one sire is to be maintained.

SILAGE MAKING ON Mr. D. SEMPLE'S FARM AT PEMBERTON.

A minimum of 2 cwt. of superphosphate is applied, in autumn and spring applications. The use of a sweep or sledge for carting, and the hoist for lifting the green material minimises labour costs. Fodder conserved for 17 cows will approximate 75 tons of silage and 20 tons of meadow hay.

2. *Prevention and Treatment of Disease.*

Prevention undoubtedly is preferable to cure where any disease is concerned, and in a dairy herd there is only *one* sure means of prevention, and that is to start with a clean herd and then breed all the replacements that are required. Many dairymen make a practice of buying cows in profit and selling later in the season as they "dry off," the herd being again replenished by further buying. It is in such herds that diseases are usually found, the three worst being mastitis, contagious

abortion, and vaginitis. The two latter diseases can be controlled definitely by avoiding the introduction of affected animals into the herd, as, without the specific germ causing the disease, its appearance is impossible.

This was very clearly demonstrated in the records of a herd under test, which the writer was privileged to see recently. This herd was commenced in 1929 by the purchase of 10 cows. Between 1929 to 1936 no purchases whatever, except two dairy sires, were made. The herd now numbers 35 milking cows, seven of which were purchased during 1936. This herd must have been clean from both abortion and vaginitis during the nine years, as no cow failed to conceive regularly, and every cow during the nine years dropped a live calf annually, except for one abortion through accident. In this herd during 212 "cow" years, the number of calves born alive was 214. Seven of the original 10 cows are still in the herd, the number of live calves dropped by each being 10, 10, 10, 9, 9, 9, and 8. Two of the original cows died during parturition and one was slaughtered after being tested, as her production was considered unprofitable by the owner.

The treatment of these three diseases is described in detail in the Bulletin "Common Stock Diseases and Their Treatment," which may be obtained free from the Department of Agriculture.

3. *Provision of Suitable Fodder.*

The provision of suitable fodder during the summer and early winter months is a problem that recurs annually and requires careful planning and forethought. The type of fodder to be utilised during these months may vary from farm to farm, but the principles governing conservation remain the same.

1. Firstly, ample fodder must be conserved, and at least 2½ tons of fodder calculated as hay is desirable. Indeed, those farmers whose herds are found among the higher producing groups conserve more than this per head. For instance, the herd owned by Mr. R. R. Graham, Fly Brook, Pemberton, consumed more than three tons of fodder per head between the months of January to May.

2. A second consideration is the type of fodder to conserve, which will vary with the situation of the farm. The basic consideration, however, is that cows require succulent food for the production of milk. In irrigated districts, therefore, hay probably would be preferable to feed with irrigated green pastures, and also during winter months.

   On unirrigated farms unquestionably silage should receive first attention. Very little silage was cut during the 1936-37 season and production suffered in consequence.

Herd Recorders report, however, that in the majority of cases hand-feeding is stinted, owing to a failure to recognise the consumptive capacity of cows. During the summer months a cow will consume 50 to 60 lbs. of silage per day, or 20 to 30 lbs. of good meadow hay, and it probably would come as a surprise to many feeders if this quantity were weighed out before being fed to find the bulk which it would represent.

Herd recorders also report that the highest average yields are obtained from those herds in which the cows are liberally fed during the summer and right up to calving. Herd test records have shown that, where good dairy cows are so fed as to be fat at the beginning of their lactation period, this fat during the first few weeks disappears, the milk during this period of "milking off" being richer in butter fat than normal. As a pound of beef fat is cheaper than a pound of butter fat, the practice must be profitable, but, in addition, the cows are in a suitable condition to turn the winter pasture into profit without first having to build up the body. The

above point may seem a small one but the writer knows many instances where "dry" cows are allowed to become low in condition although an abundance of hay has been in the shed.

An indication of the value of Herd Recording in increasing the average production of herds is shown in Table 5 below, in which the herds in both the new and older Units are grouped according to production.

Table 5.

Herds Grouped according to Production.

(Herds tested less than 273 days omitted.)

	No. of Herds.	Pounds of Butter fat per Head.				
		300–350.	250–300.	200–250.	150–200.	100–150.
Units Testing more than 1 year	167	5	26	69	56	11
	...	3%	15·5%	41·3%	33·5%	6·7%
Units Testing 1 year only ...	163	4	8	44	83	24
	...	2·4%	4·9%	27%	50·9%	14·8%

It will be seen that in the newer Associations there are approximately twice as many definitely unprofitable herds as in the older Associations, namely, those producing less than an average of 150 lbs. of butter fat per head.

In the group of doubtful profit, namely, producing from 150 to 200 lbs. of butter fat, there are no less than 51 per cent. in the newer Associations compared with 33 per cent. in the older Associations. It is in the profitable groups, however, those with over an average production of 200 lbs. of butter fat that the evidence of culling out the unprofitable cows becomes apparent, as in the older Associations 60 per cent of the herds are yielding profitable returns, while in the new Associations only 34 per cent. were definitely profitable. These figures are probably a picture of the relative productions of those herds not in the Testing Scheme, and indicate the possible results from a general adoption of Herd Recording.

For a number of reasons, not the least of which is the protection from disease, it is desirable to breed and rear such heifers as may be required for replacements.

Table 6 shows the percentage of these Junior cows in the Testing Scheme and their distribution according to production.

Table 6.

Cows Grouped according to Age and Production.

(All Cows Tested less than 100 days not included.)

Age Class.	Groups according to Butter fat Production.							Total Cows.
	Over 500lb.	400–500.	300–400.	200–300.	150–200.	100–150.	Under 100.	
	%	%	%	%	%	%	%	
Mature ...	0·07	0·73	8·80	42·38	26·61	16·34	5·07	5,781
Junior ...	...	0·01	2·75	27·00	30·62	26·21	13·41	2,655

For the purposes of this report, any cows which are under three years of age at the time of calving have been taken as "Junior" cows, and their production as "Juniors" would be approximately three-quarters of that which, on the average, they should produce at maturity.

It is surprising to note that last year nearly one-third of the cows under test were "Junior" cows, a proportion which is too high to be profitable, in view of the lower production of these young cows. If the average working age of a dairy cow be taken as six years, then a sufficient number of heifers to maintain the herd at full strength would be 1 to every 6 cows or about 17 per cent. It may be necessary in individual herds to increase this ratio considerably but, in the above Table 6, we are considering the average of 356 herds embracing 8,436 cows.

The Table also shows that a large proportion of the heifers being raised are unprofitable and unlikely to be heavy producers, namely, rather more than one-third produce less than 150 lbs. of butter fat per lactation period. Where the dams in the herd are grade cows, it is inevitable that a large proportion should be unproductive, especially in the early years of testing. It is with the hope of reducing the risk of rearing unprofitable producers that the Calf Marking Scheme was introduced at the beginning of last season and also an effort made to record those bulls which were throwing daughters of high production. See list hereunder.

Where such "proved" dairy sires can be obtained, heifers may prove as profitable as mature cows as is shown by the three heifers sired by the bull "Longlands Fowler" which unfortunately was destroyed before his value was known. These three heifers owned by Mr. S. Bowers, Brunswick, produced an average of 340 lbs. of butter fat each, and thereby won the "Mitchell Cup" presented annually for the three highest producing heifers in any one herd.

A GRADE GUERNSEY, PROGENY OF A "PROVED" GUERNSEY BULL.

Mr. G. B. Omedei's "Queenie": Calved August, 1937. 224 lbs. of butter fat in four months.

"PROVED BULLS."

It is a fact recognised by all observant dairy farmers, who have kept records of production for several years, that all dairy sires do not possess the capacity for producing high yielding daughters to the same degree. In a stud herd of pure bred cows disappointing results may be obtained for two reasons connected with breeding, firstly that the bull in question does not possess the characters resulting in high production in the progeny, or, secondly, the particular strain of blood in the bull does not "nick" with perhaps an entirely different pure strain in the females. For this reason a Stud Breeder usually endeavours to secure a sire with the blood of the same outstanding individuals in his pedigree as in those of the females with which he is to be mated.

With "grade" females, however, as their blood is not pure, the second consideration is of little importance, and the problem reduces itself to the selection of a sire which is prepotent for butter fat production to at least as great a degree as the cows with which he is to be mated.

Elaborate systems have been worked out for selecting such animals, usually based on the butter fat production of relatives of varying degrees of propinquity, but in the final issue three to four years must elapse before definite information is available regarding the production of a bull's daughters. This means that, before a dary sire can be "proved," he will be at least five years old.

With a view to assisting dairy farmers to recognise these "proved" bulls, and also to prevent their premature slaughter, a list has been compiled of the names of all those bulls which have six or more daughters that have been tested. Although 355 herds were tested during the year only 69 bulls were recorded as having six or more daughters under test.

The necessity for information outlined above is shown from the fact that of these 69 bulls, only 53 bulls, or 77 per cent., have proved successful sires, as far as the records show. The names of these bulls, their owner, and particulars regarding the production of their daughters are given in Table 7.

In view of the comparative scarcity of these "proved" bulls, it is hoped that all daughters of these sires, which are from cows testing over 250 lbs. of butter fat, and so eligible for identification under the Calf Marking Scheme initiated this season, should be registered. It is by this means that the average production of all Danish cows has been increased from 85 lbs. butter fat per cow since 1885 to the present remarkably high average of 257 lbs. per cow.

Herds grouped according to Production and Size.

The following four tables 8 to 11, in which herds have been grouped according to size and production, bring out several interesting points.

Table 8.

Group 1.—*High Producing Herds of less than* 20 *Cows.*

(In order of Merit).

Owner.	Association.	No. of Cows.	Breed.	Average lbs. Butter-fat.	—
L. C. Field	Preston-Brookhampton	8	Jersey ...	325	D.F.
W. J. Morgan	Manjimup	10	do. ...	317	D.F.
L. A. House	Coolup-Pinjarra ...	18	do. ...	310	D.F.
R. J. Trigwell	Donnybrook	18	do. ...	309	D.F.
C. J. Cunningham ...	do.	15	do. ...	299	D.F.
L. R. Maidment ...	Capel	12	Shorthorn	292	D.F.
M. Brennan	Balingup	12	Jersey x ...	287	D.F.
E. Holthouse	Harvey	13	Jersey ...	282	Ir.
Misses E. & I. Rutherford	Albany	10	Guernsey...	280	D.F.
Hill & James	do.	10	do. ...	275	D.F.
Mrs. E. A. Smith ...	Rosa Brook	12	Jersey ...	272	D.F.
F. Richards	Dardanup	15	do. ...	271	D.F.
Quongup Estate ...	Balingup	16	do. ...	270	D.F.
S. E. Robinson... ...	Forest Grove ...	17	do. ...	260	D.F.
A. C. Frost	Donnybrook	14	do. ...	259	D.F.
G. Scott	Serpentine	15	...	257	D.F.
Mrs. Eckersley	Harvey	19	Jersey ...	254	Ir.
A. Clifford	Donnybrook	14	do. ...	253	D.F.

D.F. = "Dry" Farm. Ir. = Irrigated.

TABLE 7.

Bulls with Six or more Daughters which have Produced not less than 200lbs. Butter-fat.

Sire's Name.	No. Daughters Tested.	Average Test.	lbs. Butter Fat.		Owner's Name.	Unit.	Age of Bull (if still living).
			Average Production.	Average Production with Age allowances.			
JERSEY :		%	lbs.	lbs.			Years.
Capel's Noble	6	4·85	311	371	A. & A. E. Millar	Forest Grove	12
Sweet Duke of Grass Vale	13	5·71	322	370	A. Trigwell	Donnybrook	10
Noble Fowler of Grass Vale	6	5·64	317	365	E. M. Rose	Serpentine	10
Melrose Lost Key	7	5·12	272	322	Mrs. D B. Rose....	Brunswick	8
Longlands Fowler	14	5·19	291	321	S. Bowers	do.	10
Maxon Starbright's Prince	6	5·15	265	318	A. & A. E. Millar	Forest Grove	9
Garden Hill Silver King	8	5·37	252	314	....	Harvey	6
Ventonia Fowler's Masterpiece	6	5·1	245	296	Mrs. D. B. Rose	Brunswick	7
Perrie's Masterpiece of Grass Vale	6	5·06	289	289	A. E. Jackson	do.	....
Eurach Moonlight	6	4·71	264	288	J. Angell	Rosa Brook	9
Major of Mylor	13	4·9	242	284	S. C. Maldment....	Balingup	....
Garden Hill Altitude	7	5·4	284	284	Gibbs Bros.	Harvey	8
Garden Hill Starbright Prince	10	4·6	237	283	F. O. Nelson	Balingup	7
Don Juan	9	4·9	276	283	do.	do.	8
Graceful Lad of Greenmount	14	5·17	268	282	L. Temple	Harvey	10
Ettie's Hero of Juadine	8	5·9	256	276	F. Richards	Dardanup	14
Eurack Red Cloud	6	4·65	237	276	A. & A. E. Millar	Forest Grove	9
Sabina Vale Airie	6	4·7	209	269	do.	do.	5
The Speculator	9	5·1	230	268	A. Tomerini	Balingup	9
Nooka King Twylish	6	4·63	215	263	S. West	Forest Grove	8
Basso Chief	7	5·23	263	263	L. C. Field	Brookhampton	....
Staghorn Butter Masterpiece 2nd	13	5·5	258	261	Mrs. D. B Rose	Brunswick	7
Springpark Marinora's Starbright	17	5·2	241	258	P. B. Widdup	Balingup	10
Prince Carlos	9	5·02	212	257	H. Scarr	do.	6
Carlaminda Milkmaid's Masterpiece	7	5·05	205	253	R. A. Clifton	Brunswick	10
Carnation's Peter	6	5·1	223	252	H. Scarr	Balingup	....
Grantham Fowler King II	8	4·74	240	248	T. B. Davidson....	do.	10
Pilot of Goongarry	6	4·67	202	245	W. P. Marris	Forest Grove	8
Roseworthy Majestic	7	4·78	239	244	J. A. Nilsson	Rosa Brook	8
Topsy's Sweet Duke of Grass Vale	6	4·84	204	239	E. J. Manning	Uduc	11
Banyarra Court Page	5	4·6	207	236	H. L. Holland	Forest Grove	9
Melrose Spiriter	6	4·95	227	231	do.	do.	8
Lily's Prince of Grass Vale	6	4·76	213	230	A. A. Brooks	do.	13
The Mount Beauty's Boy	15	4·88	189	229	T. H. Ellis	Balingup	7
Chapman Harpist	7	4·7	188	214	G. Hurley	Rosa Brook	13
Gentle Signal of Sarnia	20	4·11	209	209	Fairbridge Farm	Pinjarra	12
Melrose Sultan	8	4·79	169	204	A. G. Scott	Dardanup	9
The Wold Easter Lad	20	5·2	163	203	H. Bradshaw	Brookhampton	6
White's Gay Lad	21	4·8	176	200	G. E. White	Balingup	8
AUSTRALIAN ILLAWARRA SHORTHORN :							
Paddy of Berry	17	4·06	315	315	A. S. Warburton	Brunswick	14
Ernest of Claremont....	7	4·33	301	313	T. Jamieson	Capel	10
Baron of Nyrup	12	4·4	236	274	F. Reeve	Brunswick	7
Ida's Lad of Boongarra	6	4·24	223	267	C. L. Clarke & Co.	do.	....
Minathorpe Bruce	25	4·33	212	234	Fairbridge Farm	Pinjarra	10
Final of Waterside	16	4·13	213	213	A. Brazier	Balingup	13
Roosevelt of Telyarup	7	4·09	197	206	J. R. Forrest	Brookhampton	13
GUERNSEY :							
Wollongbar Mandate	6	4·46	222	256	J. H. Oldfield	Forest Grove	12
Wollongbar Distinction	6	4·8	242	247	R. Buller	do.	11
Koojan Golden Dividend	10	4·53	231	244	G. B. Omodei	Pemberton	8
FRIESIAN :							
Dunmore Ivanhoe	6	3·59	314	352	W. Taylor	Serpentine	8
Dunmore Duncan	6	3·57	213	260	Geo. Bett	do.	6
AYRSHIRE :							
Creamery Prince	6	4·42	291	291	W. & T. P. Harris	Dardanup	....
Tipperary Moonlight	10	4·1	289	289	do.	do.	13

In Group 1 are found those herds with less than 20 cows and an average production of over 250 lbs. of butter fat per cow.

Two factors stand out in this table, firstly the preponderance of Jersey herds in this group, and secondly the excellent results obtained on "dry" farms made possible only by adequate fodder conservation and arranging for the lactation periods to commence in April or May each year so that cows are able to make the best use of the green feed.

The Jersey is popular wherever the area of the farm is limited and butter fat, rather than milk, is required. One, therefore, would expect Jerseys to predominate in the smaller herd group, and, as will be seen, the areas are those in which fat is needed for supply to butter factories.

In Table 9 similar information is given for herds embracing 20 to 40 cows.

Table 9.

Group 2.—*High-Producing Herds of from 20 to 40 Cows.*

(In order of merit.)

Owner.	Association.	No. of Cows.	Breed.	Average lbs. Butter-fat.	—
J. Angell	Rosa Brook	22	Jersey ...	332	D.F.
O. Foan	Donnybrook	21	do. ...	319	D.F.
Ellis Bros.	Brunswick	37	Shorthorn	305	Ir.
F. Byrd	Harvey	28	Friesian ...	303	Ir.
S. C. Maidment ...	Balingup	25	Jersey x Shorthorn	301	D.F.
S. Bowes	Brunswick	25	Jersey ...	293	Ir.
A. Trigwell	Donnybrook	26	do. ...	290	D.F.
T. Jamieson	Capel	29	Shorthorn	285	S.L.
A. Tomerini	Balingup	27	Jersey ...	285	D.F.
K. E. Kentish ...	Serpentine	33	do. ...	283	D.F.
J. D. L. Jones ...	do.	26	Friesian ...	277	D.F.
A. F. Dean	Benger	29	Jersey ...	275	D.F.
W. J. Sears	Donnybrook	27	do. ...	273	D.F.
D. D. Johnstone ...	Harvey	26	do. ...	271	Ir.
N. Ranson	Rosa Brook	25	do. ...	268	D.F.
W. Shaw	Uduc	26	Shorthorn	266	Ir.
A. R. Testar	Cookernup	20	...	262	D.F.
F. O. Nelson	Balingup	24	Jersey ...	262	D.F.
R. Camden	Benger	23	...	261	D.F.
L. G. Gibbs	Harvey	25	Jersey ...	255	Ir.
G. S. Blaikie	Rosa Brook	21	do. ...	254	D.F.
J. Gilmour	Dardanup	28	do. ...	253	D.F.
D. Farley	Capel	34	Ayrshire ...	252	D.F.

D.F. = "Dry" Farm. Ir. = Irrigated. S.L. = Summer Land.

In this group special mention should be made of the herd of grade Jerseys owned by Colonel J. Angell, Rosa Brook, the average production of which is the highest in the Scheme. Owing to the small area of pasture, about 70 acres, Colonel Angell found it necessary to feed some concentrates during the early winter months, because, as useful rains did not fall until May, winter herbage was not available until six or seven weeks later. The quantity of concentrate used was not large,

being 2 lbs. of bran and 1 lb. of pollard per day to those cows that needed it. Although every effort should be made to avoid the use of concentrates, the feeding of them is justified with high producing cows, if these cows would fall away in condition without them.

HIGHEST PRODUCING HERD IN THE HARVEY UNIT.

Mr. F. Byrd's milking shed. Note gravelled yard to avoid muddy conditions during winter months. This herd of 28 Grade Friesians produced 303 lbs. of butter fat per cow during 1936-37.

Messrs. Ellis Bros.' herd at Brunswick with a production of 305 lbs. butter fat per cow also deserves special mention, owing to the size of the herd and the necessity of maintaining a summer supply of milk for consumption as whole milk. Messrs. Ellis Bros. have the advantage of approximately 20 acres of well-managed permanent irrigated pasture consisting of Perennial Rye Grass, Paspalum, and White Clover, which undoubtedly has been a factor whereby the herd average has been raised from 276 lbs. in 1935-36 to 305 lbs. butter fat per cow in 1936-37.

The herds placed second and third in Table 9 and owned by Messrs. O. Foan and Ellis Bros. respectively are good examples of results which may be obtained by culling in the case of Mr. Foan, and improved management and feeding in conjunction with culling in the case of Messrs. Ellis Bros.

Year.	O. Foan, Donnybrook.		Ellis Bros., Brunswick.	
	A good Herd improved.		A poor Herd improved.	
	No. of Cows.	Butter-fat per Cow.	No. of Cows.	Butter-fat per Cow.
		lb.		lb.
1934	14	210	47	145
1935	20	272	39	216
1936	18	325	34	277
1937	21	319	37	305

A GOOD "LOOKING" COW, BUT UNPROFITABLE.

"Susy" in the Pemberton Unit. 1936-37: Calved September, 1936. 108 lbs. butter fat. 1937: Calved August, 1937. 120 lbs. and drying off.

In Table 10 are shown the particulars of herds of from 41 to 60 cows and average productions above 200 lbs. butter fat per herd.

Table 10.

Group 3.—*High Producing Herds of from* 41 *to* 60 *Cows.*

(In order of Merit).

Owner.	Association.	No. of Cows.	Breed.	Average lbs. Butter-fat.	—
A. S. Warburton ...	Brunswick	45	Shorthorn	261	Ir.
A. & A. E. Millar ...	Forest Grove ...	43	Jersey ...	243	D.F.
T. W. Hakesley ...	Brunswick	43	Shorthorn	241	Ir.
A. J. V. Doley ...	Serpentine	53	do. ...	240	D.F.
C. A. Wickham ...	Cookernup	47	do. ...	236	D.F.
J. H. Brett	Dardanup	47	Jersey ...	231	Ir.
D. Scott	Balingup	48	do. ...	230	D.F.
T. W. Taylor	Serpentine	44	Friesian ...	225	D.F.
H. P. Fry	Benger	42	Shorthorn	223	Ir.
T. B. Stanley	do.	42	do. ...	220	Ir.
R. C. Williams ...	Bridgetown	45	Jersey ...	215	D.F.

D.F. = "Dry" Farm. Ir. = Irrigation.

Mr. A. S. Warburton, whose milk contracts require him to maintain a minimum production throughout the whole year, has increased his herd from 35 to 45 cows during the season and has maintained production at the same average figure; another triumph for irrigated pasture. This herd has been under test since the

inception of the Scheme in 1934, and the annual records are interesting as showing consistent improvement.

Year.	No. of Cows.	Butter-fat per Cow.	Total Butter-fat for Herd.
		lbs.	lbs.
1934	40	184	7,360
1935	42	235	9,870
1936	38	260	9,880
1937	45	261	11,745

Table 11 sets out the largest herds, those of over 60 cows, the average production of which exceeded 200 lbs. butter fat per cow.

TABLE 11.

GROUP 4.—*Herds over 60 Cows.*

Owner.	Association.	No. of Cows.	Breed.	Average lbs. Butter-fat.	—
J. P. Norton	Capel	85	Shorthorn	216	S.L.
G. Dempster	Benger	70	Jersey ...	215	D.F.
Mrs. D. B. Rose ...	Brunswick	64	do. ...	211	Ir.
Fairbridge Farm ...	Pinjarra	70	Shorthorn	208	D.F.
L. Busquets	Capel	98	Jersey ...	204	D.F.

D.F. = "Dry" Farm. Ir. = Irrigated. S.L. = Summer Land.

In large herds, such as those mentioned in Table 11, the individual cow tends to lose her identity; she is not observed or studied as a rule so closely as individual cows in smaller herds, and in such herds testing is of special value as indicating the profitable and unprofitable producers.

The production of Mr. Norton's herd is of special interest as showing rapid improvement by rigid culling, and also the difficulty of maintaining high production in a large herd; the reason for the fall in this instance was undoubtedly the adverse season experienced in 1936-37.

Year.	J. P. Norton, Capel.		L. Busquets, Capel.	
	No. of Cows.	Butter-fat per Cow.	No. of Cows.	Butter fat per Cow.
		lbs.		lbs.
1934	64	169	155	124
1935	71	182	148	177
1936	71	255	150	215
1937	85	216	98	204

As mentioned before, the season 1936-37 was an unfavourable one for pasture production as is shown by the distribution of rainfall given below for the Balingup district during 1936 and during the present year up to November, 1937. The relative rainfall in this district may be taken as typical of that which occurred throughout the South-West during the two seasons.

MONTHLY RAINFALL FOR YEARS 1936 AND 1937.

Year.	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total (inches
1936	23	6	36	97	308	482	332	904	210	96	48	42	25·84
1937	....	84	338	640	960	733	331	568	319	303	212 inclusive	....	43·89 inclusive

It will be seen from these rainfall records that useful rains did not commence until May, 1936, which means that good grazing would not be available until late July. Useful rains did not fall after the end of September, so that the flush period which is usually during October and November was almost lacking in 1936, the total wet months being from May until September.

In 1937 useful rains fell two months earlier, in March, and good grazing was available in May. Owing to the continuance of moist conditions until November, a longer flush period than usual is being experienced.

Mr. J. SALERIAN'S DAIRY PREMISES AT WAROONA.

The cows are fed in the bails in the left foreground and pass into the milking shed through a concrete race. Hay shed in the background accommodates approximately 100 tons of hay.

In spite, however, of the shorter "grazing year" in 1936, the number of herds which exceeded 250 lbs. butter fat per cow, and the number of cows which exceeded 400 lbs. butter fat each are the greatest recorded since the inception of the scheme.

A list of the 20 leading cows is shown in the following table:—

Table 12.

TWENTY LEADING COWS—ALL UNITS.

Owner.	Unit.	Name of Cow.	Breed.	Tattoo.	Test.	Butter-fat.
					%	lbs.
T. Jamieson	Capel	Betty I.	Shorthorn	G.S. 6	5·46	561·16
R. J. Trigwell	Donnybrook	Buttercup	Jersey	A.E. 4	5·75	546·75
T. Jamieson	Capel	Betty II.	Shorthorn	G.S. 1	5·66	518·35
Ellis Bros.	Brunswick	Tiger	Shorthorn	E.B. 15	4·87	497·70
D. L. Jones	Serpentine	Whiteface	Friesian	B.J. 1	4·37	482·74
L. G. Gibbs	Harvey	Mary	Jersey	D.N. 19	4·88	480·63
S. Bowes	Brunswick	Biddy	Jersey	E.E. 38	4·83	478·32
J. V. Doley	Serpentine	Blossom	Shorthorn Guernsey	B.A. 30	5·66	478·00
J. Angell	Rosa-Brook	Annabelle	Jersey ×	K.B. 15	4·97	477·00
Ellis Bros.	Brunswick	Jenny	Jersey	E.B. 10	5·08	475·32
A. F. Dean	Benger	Blossom	Guernsey × Jersey	E.W. 28	5·10	463·95
R. C. Williams	Greenbushes	Maggie	Jersey	Q.S. 23	4·92	462·70
Hill & James	Albany	September	Jersey × Guernsey	S.Z. 1	5·28	452·22
O. Foan	Donnybrook	Pansy	Jersey	A.L. 14	5·40	444·96
E. & I. Rutherford	Albany	Biddy	Jersey × Ayrshire	S.D. 4	4·38	442·45
J. Angell	Rosa Brook	Carmen	Jersey ×	K.B. 19	4·68	441·46
R. J. Trigwell	Donnybrook	Gertie	Jersey	A.E. 19	5·18	438·69
T. A. Fenning	Forest Grove	Melba	Guernsey	L.N. 7	4·01	435·82
T. Jamieson	Capel	Pickles	Shorthorn × Jersey	G.S. 8	5·46	434·64
G. Scott	Serpentine	Joan	Friesian	B.U. 16	3·76	433·68

PROGENY OF "PROVED" GUERNSEY BULL, KOOGAN GOLDEN DIVIDEND.

One of the ten heifers owned by Mr. G. B. Omedei, all sired by Koogan Golden Dividend. Average production 244 lbs. of butter fat on first calf.

The cup donated by the directors of the South-West Co-operative Dairy Farmers Ltd. to be held by the owner of the four highest producing cows in any herd being tested under the Grade Herd Recording Scheme has been won this

season by Mr. T. Jamieson, of Capel. The grade Shorthorn herd owned by Mr. Jamieson has been consistently near the head of the Capel unit since the inception of the scheme, and it is pleasing to note that the cows in this herd had not received any concentrates of any kind except such as may be grown on the farm.

The following are the individual records of Mr. Jamieson's four cows:—

Name of Cow.	Milk.	Butter-fat.
	lbs.	lbs.
Betty 1st	10,269	561·16
Betty 2nd	9,147	518·35
Pickles	7,950	434·64
Melba	8,427	412·91
Average	8,948	481·76

The present season has afforded an excellent illustration of the importance of having an abundant supply of nutritious fodder for dairy cows if the best results are to be obtained, and it is hoped that every opportunity will be taken to conserve as much as possible of the surplus fodder at present available as a standby for less propitious seasons.

THE "WHITE" METHOD OF MAKING SILAGE, BALINGUP.

Mr. G. White, Balingup, claims the method to be rapid, labour-saving and effective. Green material is brought to a central spot by sweeps, the horse being driven over the heap until a round mound is formed. The ground round the heap is ploughed, and the loose earth scraped with a one-horse scoop over the mound. Very little waste has resulted during the two years the method has been used.

The following table shows the monthly production from May to October for the years 1936-37 in the Balingup unit. The percentage yields in other units are

very similar to those at Balingup, although space does not permit of their inclusion.

TABLE 13.

THE EFFECT OF AMPLE PASTURE ON BUTTER-FAT PRODUCTION.

Month.	Butter-fat per Cow (1936).	Butter-fat per Cow (1937).	Percentage Increase.
	lbs.	lbs.	lbs.
May	22·5	32·1	44·4
June	25·2	35·4	40·1
July	26·7	36·7	37·3
August	28·7	35·8	25·1
September	33·6	35·7	6·2
October	34·4	34·7	·85

The above table shows, as would be expected in view of the early commencement of useful rains in 1937, that the biggest percentage increase would be noticed in the autumn months.

By the end of October sufficient fodder is available in any year, however unfavourable it may be, as a total failure of the rainy season has been unknown in the South-Western districts. This is another reason why cows should commence their lactation period early in the autumn so as to be in a condition to take advantage of any unusually good seasons which may occur.

The following table No. 14 is a record of the average production of each herd in the 18 units which were under test during the season 1936-37:—

TABLE 14.

Donnybrook "A."	No. of Cows.	Butter-fat. average.	Serpentine. "B."	No. of Cows.	Butter-fat. average.	Cookernup. "C."	No. of Cows.	Butter-fat. average.
O. Foan	21	319·03	E. J. Kentish	33	283·49	A. R. Testar	20	262·03
R. J. Trigwell	18	309·36	D. L. Jones	26	277·72	Homebush S.F.	16	238·46
C. J. Cunningham	15	299·40	G. Scott	15	256·55	C. A. Wickham	47	235·88
Herd T	26	290·26	Herd H	22	249·53	Herd S	15	233·7
,, A	27	273·77	,, A	53	240·56	,, P	23	223·1
,, C	14	259·18	,, G	21	236·55	,, B	28	212 8
,, G*	14	253·04	,, T	44	225·71	,, 6C	30	205
,, W	11	239·12	,, S	27	201·91	,, 3C	22	198·8
,, D	23	237·25	,, I	25	192·48	,, A*	13	194·99
,, K	22	235·13	,, E	14	184·04	,, 7C	51	187·44
,, Z	28	232·74	,, F†	20	171·83	,, 1C	38	186·1
,, E*	19	215·81	,, P	31	169·17	,, T	27	185·9
,, F	29	209·17	,, N	9	162·88	,, L	30	183·76
,, C*	19	206·31	,, D	19	162·80	,, W	21	183·2
,, A2	14	201·06	,, M	14	155·73	,, J	33	168·6
,, K*	19	197·60	,, C	20	151·96	,, CS	56	166·6
,, F*	17	194·81				,, Q	22	164·8
,, X	14	183·70				,, H	9	156·4
,, U	22	170·85				,, 2C	10	153·8
,, A*	18	167·01				,, B*	11	147·5

* Letter reversed. † Tested six months only.

TABLE 14—*continued.*

Harvey "D."	No. of Cows.	Butter-fat average.	Brunswick "E."	No. of Cows.	Butter-fat average.	Dardanup "F."	No. of Cows.	Butter-fat average.
		lbs.			lbs.			lbs.
F. Byrd	28	303·00	Ellis Bros.	37	305·44	F. Richards	15	270·57
E. Holthouse	13	282·80	S. Bowers	25	293·19	C. Gilmour	28	253·05
D. D. Johnstone	26	271·15	A. S. Warburton	45	261·28	W. H. Harris	20	245·98
Herd N	25	255·23	Herd J*	22	253·49	Herd D*	17	240·81
,, E	19	254·05	,, H	34	242·11	,, V*	24	232·11
,, AF	31	248·15	,, V	43	241·67	,, A	47	230·7
,, C	18	246·53	,, C*	38	237·68	,, AH	30	229·06
,, AJ	20	231·95	,, M*	36	237·56	,, W	12	215·56
,, G	34	220·29	,, A*	25	234·39	,, AG	10	211·08
,, AH	9	224·69	,, U	29	231·85	,, AC	20	211·07
,, AK	16	223·54	,, E*	18	230·08	,, 5	19	195·93
,, AL	19	217·44	,, Q	26	217·97	,, K	39	188·93
,, O	31	208·80	,, D*	22	214·34	,, AE	16	181·55
,, R	33	207·75	,, B*	64	210·84	,, AJ	33	171·13
,, B	27	203·04	,, E	31	207·92	,, AB	32	166·13
,, P	33	191·28	,, K*	30	205·72	,, Q*	44	164·04
,, AG	17	173·45	,, L*	51	204·54	,, AK	49	163·33
,, AD	27	166·13	,, A	33	198·39	,, G*	34	159·16
,, W	26	165·82	,, X	38	196·77	,, AD	69	153·22
,, V	45	156·14	,, G‡	60	189·88	,, U	22	144·51
						,, AI	63	143·89
						,, AL†	48	135·6
						,, T	40	132·04
						,, T*	20	129·63

* Letter reversed. ‡Under test 7 months only. † Under test 4 months only.

Capel "G."	No. of Cows.	Butter-fat average.	Balingup "H."	No. of Cows.	Butter-fat average.	Forest Grove "I."	No. of Cows.	Butter-fat average.
		lbs.			lbs.			lbs.
L. R. Maidment	12	292·23	S. C. Maidment	25	301·54	S. E. Robinson	17	259·96
T. Jamieson	29	285·53	M. Brennan	12	287·47	S. A. Fenning	26	249·88
D. Farley	34	252·61	A. Tomerini	27	285·45	A. & A. E. Millar	43	243·47
Herd C	24	246·31	Herd B*	16	270·40	Herd H	14	222·77
,, A	85	216·31	,, U	24	261·84	,, L	17	219·67
,, H	37	206·17	,, P	25	236·01	,, K	17	218·37
,, L	98	204·33	,, N	26	230·79	,, M	28	217·66
,, F§	42	184·44	,, K	48	230·43	,, T	15	216·04
,, E	44	181·09	,, T	24	229·09	,, D	28	206·21
,, N §	30	176·95	,, V	32	229·03	,, J	17	204·89
,, X §	40	170·39	,, D	22	227·94	,, Z	17	200·57
,, V	77	143·56	,, Q	15	225·26	,, Y	15	194·44
,, T	53	127·89	,, C*	18	208·73	,, O	22	193·54
			,, C	50	196·52	,, R*	18	190·32
			,, A*	51	190·48	,, Q	15	176·49
			,, H7	17	187·16	,, A	18	175·35
			,, H5	22	171·27	,, B	24	174·09
			,, H4	17	151·98	,, W	16	169·10
			,, M	33	147·49	,, C	8	159·64
			,, H8	36	142·89	,, A*	14	158·16
			,, H6	16	121·28	,, E	17	145·74
						,, X	17	141·27

* Letter reversed. § Tested six months only.

Pemberton "J."	No. of Cows.	Butter-fat average.	Rosa Brook "K."	No. of Cows.	Butter-fat average.	Manjimup "M."	No. of Cows.	Butter-fat average.
		lbs.			lbs.			lbs.
R. R. Graham	16	244·59	J. Angell	22	332·60	W. J. Morgan	10	317·52
G. B. Omodei	25	243·12	Mrs. E. A. Smith	12	272·87	R. M. Davies	15	243·99
D. Bendotti	16	210·32	N. Ranson	25	268·81	M. Kilrain	15	233·29
Herd P	20	201·38	Herd L	21	253·78	Herd E	13	215·01
,, L	17	198·39	,, M	26	230·34	,, X	20	209·85
,, B	18	193·71	,, U	20	220·94	,, C	23	207·88
,, D	34	193·58	,, C	18	215·46	,, B	24	204·48
,, I	57	189·94	,, O	19	209·62	,, A	47	196·01
,, M	22	185·80	,, Q	12	206·56	,, N	16	192·47
,, N	12	182·88	,, N	14	200·47	,, H	18	186·53
,, E	35	173·73	,, H	32	191·41	,, P	21	183·31
,, T	12	173·72	,, F	28	185·51	,, U	15	181·61
,, H	16	166·25	,, D	41	184·62	,, R	17	178·06
,, S	44	166·22	,, R	25	184·00	,, S	29	174·85
,, R	27	164·35	,, S	23	180·27	,, T	19	155·27
,, Q	21	157·70	,, W	16	172·82	,, G	28	151·84
,, A	10	143·68	,, J	24	166·79	,, Q	24	150·99
,, C	12	136·92	,, X	17	161·48	,, V	17	144·72
,, K	20	132·29	,, E	17	161·06	,, W	14	135·80
,, F	21	126·84	,, Y	18	150·61	,, F	17	134·21
			,, P	22	143·17	,, Y	52	119·77
			,, T	19	137·02			
			,, G	21	131·93			

TABLE 14—*continued.*

Uduc "N."	No. of Cows.	Butter-fat average.	Benger "O."	No. of Cows.	Butter-fat average.	Coolup-Pinjarra "P."	No. of Cows.	Butter-fat average.
		lbs.			lbs.			lbs.
W. Shaw	26	266·10	A. F. Dean	29	275·57	L. A. House	18	310·66
P. MacNeill	36	235·03	R. Camden	23	261·31	F. G. Williams	23	219·32
E. J. Manning	30	233·14	S. Carlsson	29	231·79	Johnson Bros.	10	215·80
Herd L	15	224·12	Herd J	42	223·85	Herd U	18	212·90
„ B	21	202·48	„ M	42	220·44	„ T	70	208·26
„ J	17	196·90	„ N	29	217·63	„ F	19	202·19
„ A	19	184·77	„ E	70	214·99	„ G	22	195·64
„ E	14	183·00	„ L	30	209·17	„ B	29	182·54
„ M	19	170·47	„ B	13	207·12	„ V	10	179·60
„ R	30	167·76	„ H	27	202·86	„ R	55	178·17
„ F	36	156·55	„ F*	46	197·16	„ A	19	176·63
„ D	36	154·66	„ P	58	192·23	„ D	26	170·08
„ N	17	154·44	„ G	42	177·03	„ J	28	167·45
„ K	15	149·05	„ R	24	176·28	„ Q‡	18	156·44
„ O	20	124·05	„ C	42	165·57	„ S	39	154·15
			„ K	19	159·74	„ H	21	153·57
			„ A	50	144·73	„ C	27	150·15
			„ O§	36	139·15	„ I	34	149·96
						„ K	17	146·18
						„ E	19	138·94
						„ N†	11	133·9

‡ Tested 5 months. † Tested 7 months. § Tested 6 months. * Letter reversed.

Catterick-Green-bushes "Q."	No. of Cows.	Butter-fat average.	Preston-Brook-hampton "R."	No. of Cows.	Butter-fat average.	Albany.	No. of Cows.	Butter-fat average.
		lbs.			lbs.			lbs.
F. Heywood	24	236·59	L. C. Field	8	325·81	Misses E. & I.	10	280·96
R. C. Williams	45	215·78	E. J. Kemp	10	243·28	Rutherford		
A. Lindsay	25	215·26	E. A. Crute	18	228·06	Hill & James	10	275·54
Herd C	28	205·83	Herd N	9	223·72	F. R. H. Pugh	14	220·56
„ V	26	201·02	„ I	20	212·05	Herd V	10	194·19
„ X	26	194·64	„ C	8	210·63	„ M	7	192·47
„ N	21	175·23	„ X‡	15	204·07	„ F	10	190·97
„ B	26	170·01	„ U	29	199·71	„ E	17	183·56
„ P	32	169·45	„ Q	17	195·95	„ R	12	173·74
„ L	21	165·56	„ S	14	187·29	„ U	13	172·13
„ A	30	162·85	„ W	10	176·75	„ I	35	170·15
„ O	17	161·61	„ P	12	174·99	„ H	44	170·06
„ Z	66	154·21	„ L	13	170·05	„ A	32	169·71
„ F	23	150·68	„ F	17	164·45	„ P	11	148·21
„ U	53	147·45	„ G	34	156·80	„ G†	15	141·31
„ R	16	143·67	„ O	13	154·99	„ X	20	140·44
„ J	14	142·04	„ K	12	153·52	„ C†	16	138·13
„ D	14	131·15	„ D	20	151·19	„ W†	7	131·36
„ T	25	126·68	„ R	14	124·19	„ O	11	128·78
„ G	39	105·69	„ H	22	92·76	„ K	20	124·54
						„ Q†	11	116·27
						„ T	46	80·68
						„ N†	17	71·62

‡ Tested 7 months. † Tested less than 273 days.

"POTASH DEFICIENCY SYMPTOMS."

By Prof. Eckstein, Dr. A. Bruno and Dr. J. W. Turrentine.

(Pp. 235. 54 coloured plates, 41 figures. Verlagsgesellschaft fur Ackerbau, Berlin S.W.11, RM 5.70. Australian orders through Pacific Potash Limited, Sydney. 12s. 6d.)

A REVIEW.

At a time when efficiency in crop manuring is of paramount importance to agriculturists generally, the appearance of this book is most opportune. Particularly in Western Australia where superphosphate is the dominant fertiliser, and, with many crops the only fertiliser used, it is of importance to consider the need for other manurial ingredients such as potash, nitrogen boron manganese, zinc, copper, etc. The continued use of superphosphate makes increased demands on the supplies of other plant requirements and it can readily be understood that on many soils reduced yields owing to depletion of elements such as potash will ultimately result. Furthermore, recent research work indicates that combination with phosphates may render potash unavailable and it is apparent that continued use of superphosphate may contribute to unavailability in this way.

The knowledge of potash salts as promoters of plant growth dates back nearly 200 years and with the growth of modern chemistry is has been possible to prove that the element potassium is essential for plant growth. Enhanced crop yields are obtained in many instances as a result of the use of potassic manures and, in addition, improvement in quality of the produce is frequently reported.

Potassium appears to act in conjunction with nitrogen in the nutrition of the plant and is an important factor in the manufacture of starches. If the soil is deficient in available potash and adequate provision is not made in manurial treatment both quantity and quality of the crop will suffer.

It is the purpose of this book which is printed in English, German and French, to bring before farmers, horticulturists and agriculturists generally the symptoms of potash deficiency in the main agricultural plants of temperate and subtropical regions and no expense has been spared in the illustration of the text by photographs, drawings and coloured plates.

By this means external symptoms and modifications of the internal structures as a result of potash deficiencies are made clear.

Accounts are also given of the influence of potash deficiency on resistance to diseases, pests and climatic factors and of the pathology of potash deficiency. Mention is made of the importance of potassium in economising water use and in the formation of plant proteins. It is shown that potash deficiency is usually accompanied by the formation of necrotic (dead) spots on the leaves; small and malformed leaves are characteristic and an unhealthy colour commonly develops.

Two contributed essays complete the text. The first by Dr. G. N. Hoffer deals in detail with maize and the second, by G. W. Cowie, M.A., B.Sc., with fruit trees in relation to the main subject.

Although other soil deficiencies may induce similar symptoms in many instances, making diagnosis difficult without extensive knowledge of field conditions, it is certain that agriculturists generally and market gardeners and horticulturists in particular will find this publication of great value as a guide to potash manuring.

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